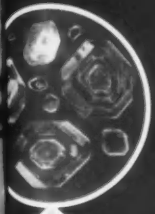
Read Guided Chemistry Tour

CHEMISTRY

Guided Chemistry Tour 1
Heat Resistant Plastics Revealed 12
New Frontiers in Science in 1958 13
Missile and Rocket Paints 15
Science Experiments Discover Ability 19
Summer Chemistry Book Announced 20
Metallurgical Bacteria Go Commercial 21
For The Home Lab: The Benzoin Condensation 23
Chemistry Quiz 25
Crystal Chemistry Encyclopedia Planned 27
The Elasticity of Rubber 31
On the Back Cover 34
Reds Reveal Future Science Plans 35
American Chemical Society Meeting
- High Altitude Craft Would Make Fuel 37
- Crystal Growing 37
- Ca Versus Sr^{90} in Soil 38
- Vital Hormone Synthesized 39
- Anti-Leukemia Drug 40
- Two Types of Diabetes 41
- Plant "Heart Attacks" 41
- Hay Fever Cause Isolated 42
- New Catalyst System 43
- Vegetable Oils Replace Tin 44
- Prof. Natta on Polymers 44

Free Radicals and Cigarette Smoke 46
Book Condensations 48

Editorial:
The Past is Prologue
Inside Front Cover



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The Past is Prologue

➤ ON THE ARCHIVES BUILDING in Washington there is the inscription: The Past is Prologue. From Shakespeare, no doubt.

A taxi driver passing by translated this as: "You ain't seen nothing yet."

So it is with chemistry. One of the great classics of chemistry interpretation and popularization was the book, "Creative Chemistry" which Dr. Edwin E. Slosson, first director of Science Service wrote during World War I. A few years ago a decision had to be made as to whether this volume that played such an important part in informing the American public should be reissued and revised.

A careful inspection of the superbly written chapters showed that no one of them could have been retained. Chemical progress had been too swift. The processes and the products had been superseded. The book was past, not current, history.

The magnificent achievements of today, some of them, will give way to future progress. Some old products will survive, and processes will be bettered and revised. But the always exciting prospect is for new discoveries and things and methods undreamt.

That is the prospect that drives onward those solidly venturesome in chemistry, whether they be young or old in years and experience.

Some of the exciting possibilities of the future are given in the article on p. 13.

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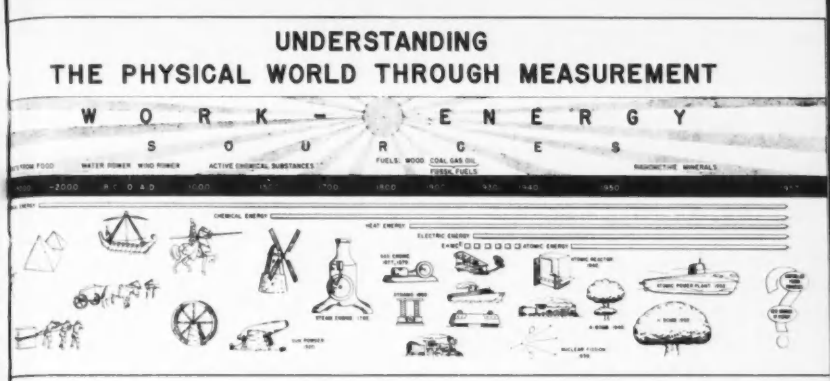


▶ MAN'S SEARCH *for new sources of energy is depicted in this schematic chronograph, the backdrop for the lecture-demonstration "Understanding the Physical World Through Measurement", filmed at the National Bureau of Standards.*

Guided Chemistry Tour

▶ I OFTEN SAY . . . *that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be.* — Lord Kelvin (1883)

Based on these words of Lord Kelvin, the National Bureau of Standards has devised and released to school use a film that demonstrates how the art and science of measurement has contributed to our knowledge of the world.

"Understanding the Physical World Through Measurement" touches on all recognized fields of physical science and shows clearly how reproducible measurements have made these sciences possible. In a sense, it becomes a course in the physical sciences presented from the view of measurements and what they mean.

Guided Tour

The film is available to schools requesting it from the Office of Technical Information, National Bureau of Standards, Washington 25, D.C. Copies are available on loan from 25 regional centers. NBS officials told CHEMISTRY that due to the limited number of copies available, schools should make their requests well in advance of proposed showings.

The film grew out of the 1957 Guest Week program at the Bureau. At that time, students were admitted to the various non-restricted labora-

tories of the sprawling institution located in the Northwest sector of the Nation's Capital.

Each of the 21 open laboratories became a guided tour "stop" designed to explain in detail the fascinations of one part of science. Many students later stated they learned considerable "hard" science — of a type taught in classes, but reaching far beyond the classrooms — at many of the stops.

The 14 stops of greatest immediate interest to students and teachers of chemistry are described in this article. The descriptions were written by the NBS staff, based upon research conducted in the laboratories represented by each stop. A 15th "stop" presented here is the fascinating story of the Bureau, what it is, what it does and how it came into being.

The Bureau and Its Work

The National Bureau of Standards was established by the Congress in 1901 to provide essential scientific services to Government, business, industry, and science. These services relate chiefly to standards and methods for accurate measurement of natural phenomena.

Today the Bureau plays a highly important and, in many ways, unique role in our modern technological economy. As the custodian of the national standards of physical measurement, it is the ultimate source in this country for the accuracy and reliability of the thousands of standards used in mass production of interchangeable parts, in the development of new products and devices, in the commercial exchange of goods, and in the measurement of scientific quantities.

The manufacturer of automotive engines depends upon standard gage blocks in producing cylinders and pistons to fine tolerances. Makers of refrigerators, television sets, and military electronic equipment depend upon accurate electrical standards and methods of measurement for the proper functioning of their products. Hospitals use radioactive standards to insure correct dosage in treatment of cancer and various other diseases. Buyers and sellers of coal, grain, and other commodities depend upon standard weights for the accuracy of railway track scales.

Develops New Methods

These and thousands of other daily operations and transactions in our economy — from the purchase of a gallon of gasoline to the determination of the mass of a nuclear particle, from the surveying of real estate to the manufacture of clinical thermometers for medical use — require national standards of physical measurement.

The Bureau's responsibility for fundamental standards does not end with their custody and maintenance. It must provide the necessary methods and instruments of measurement required to utilize these standards. Then, through calibration services, it insures the accuracy of countless industrial and scientific instruments and working standards by comparing them with the national standards.

These measurement activities demand a constant search for new scientific knowledge and methods. Research is continually conducted to meet the increasing needs of science and industry for more precise measurements. Also, as new areas of science and technology become active or productive, the Bureau develops new

standards, devises new methods and instruments of measurement, and makes appropriate calibration services available.

In recent years, for example, several additional radioactive standards have been required, as developments in atomic energy have made various radioactive materials available for medical, industrial, and basic research.

The increasing use of extremely penetrating high-voltage X-rays in medical treatment and industrial inspection of metal parts has also made necessary the development of appropriate standards and measurement methods.

Similarly, new basic standards and techniques are now needed to keep pace with advances in such fields as electronics, nuclear physics, high-frequency radio, and design of high-speed aircraft.

Basic Research

Closely related to the standards program is the work on the basic properties of matter and materials. The Bureau determines fundamental physical constants, like the acceleration of gravity, to provide the accurate values needed by scientists and engineers. It also studies, evaluates, and precisely measures the properties of materials, such as metals and plastics, providing a sound basis for their industrial and scientific utilization.

It furnishes data and techniques in devising methods of testing materials, in developing specifications for Government purchase, in developing building and safety codes, and in testing materials purchased by the Government.

The background in precise measurestandards and properties of materials enables the Bureau to serve the Govment provided by the basic work in ernment and the Nation in a variety of other ways.

For example, it renders advisory services on technical problems to other Federal agencies, as well as to many State and local governments. It invents and develops devices — such as electronic computers and radiation detection equipment — to meet the special needs of the Government. And it conducts research investigations in such fields as nuclear physics, low-temperature engineering, high polymer structure, fluid dynamics, and radio propagation.

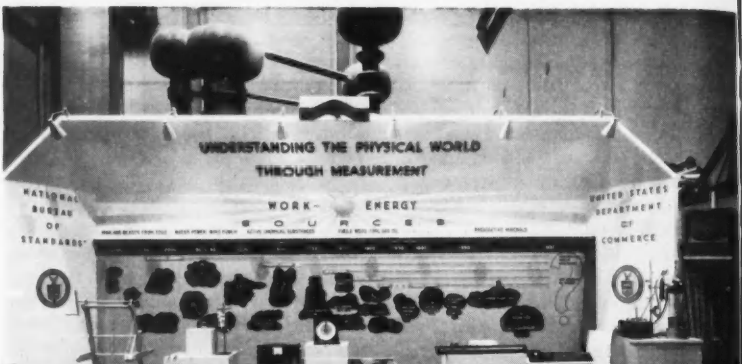
The over-all program is thus quite broad in scope, embracing a large number of different projects in physics, mathematics, chemistry, metallurgy, and various branches of engineering. Yet all these efforts in diverse areas have one single unifying theme: precise measurement of natural phenomena.

Radiation

Nuclear radiation from radioactive sources is essential in medicine for treating patients and, in industry, for radiographic inspection of materials and for inducing changes in materials by irradiation. In military, civil defense, and atomic energy programs it is used for radiation instrument development and calibration.

The Bureau's recently constructed Gamma Ray Laboratory was designed for handling small radioactive sources. Here much of the radium preparations used in treating cancer are measured, and cobalt-60 sources are calibrated for use as secondary standards.

This laboratory also tests radiation detection instruments. For this pur-



➤ THE SETTING *for the film in the High Voltage Laboratory at the National Bureau of Standards, where some 6,000 high school science students were accommodated during the Guest Week Program of May, 1957.*

pose there are three large cobalt-60 sources shielded by lead under the floor of the laboratory's High Level Room. The instruments tested include Geiger counters, ionization chamber and crystal detectors, and personnel monitoring devices such as pocket dosimeters and film badges.

A recent addition provides a large cobalt-60 source in a 12-foot-deep pool of water for the study of changes in materials when irradiated at temperatures from −270°C to +600°C. Thus far it has been used mainly to study effects of radiation on plastics and on the monomers from which they are made.

Purity of Substances

Before reliable physical and chemical properties can be established for a material, a knowledge of its purity is necessary. For example, the freezing point of a pure substance is lowered when other substances (impurities) are added, and this fact is basic for extremely precise purity measurements. Such methods — known as "cryoscopic" — are of two principal kinds: (1) the calorimetric and (2) the freezing-curve methods.

In the first method, the equilibrium melting temperatures are determined for various liquid-solid ratios which result from the addition of known

amounts of heat. In the other method, a freezing or melting curve is obtained as the sample is progressively frozen or melted while the solid and liquid phases are kept in equilibrium by stirring. In this exhibit, the freezing curve procedure for measuring the purity of highly reactive substances was demonstrated. The freezing point of a high purity sample was determined. Also a special display demonstrated visually the manner in which crystal growth in a solution produces a lowering in the freezing temperature of the remaining liquid.

Solar Energy Furnace

The further development of equipment such as jet engines and nuclear power plants is seriously limited by a lack of materials that can withstand high temperatures and pressures. Such requirements are already out of the range of most metals and even beyond the strength and refractoriness of ceramics. It has been necessary, therefore, to make fundamental studies of the physical and chemical stability of ceramic oxides, silicides and nonoxide substances under extreme conditions.

This field of investigation presents many problems not found at more ordinary temperatures and pressures. Unpredictable complex molecules may be formed; or complete reversal of a compound's normal properties may occur. Atomic structure, too, can be rearranged, resulting in new and different properties. Also, minute traces of impurities can produce profound effects on materials at extreme temperatures and pressures.

To investigate these unusual effects the Bureau has a special laboratory where a solar energy furnace can generate heat up to 4000°C (7000°F) — two-thirds as hot as the surface of the sun. In addition, a high pressure reaction chamber is used to synthesize certain minerals in their purest form. Pressures up to 1 million pounds per square inch and temperatures up to 1500°C (2700°F) can be generated. In this way it has been possible to make several artificial minerals that are more durable than their natural counterparts.

High Temperature Measurements

There is an urgent need for substances that can withstand temperatures above 2000°C (3600°F). To provide scientists and engineers with information about materials suitable for use in jet planes, rockets, guided missiles, earth satellites, and nuclear reactors, one must learn how various materials stand up under the tremendous heats generated.

The immediate task is not necessarily to develop new refractory materials by trial and error. Rather, it is more a problem of precise measurement of the physical and chemical properties of already existing materials at these high temperatures. To obtain such basic data more easily and accurately, the Bureau is developing new ways to carry out experiments at high temperatures.

Some special devices used in the program were shown in this exhibit: a vacuum chamber micro-balance to determine the relative volatility of solids at high temperature; a differential thermal analysis apparatus to study the thermodynamic changes that occur in crystalline transformations of alumina, silica and other ox-

ides; and a sonic measurements furnace to determine elastic and strength properties of refractory substances.

The Bureau's long-range program for obtaining precise quantitative data on inorganic materials which are most stable at high temperatures should lead to a better understanding of the chemistry and physics of refractories.

Story of Energy

Energy is the ability to perform work, and from earliest times man has had to work to live. Thus, the story of man's search for sources of energy is the story of man himself. The chart on page one outlines his continuing struggle to harness the various forms of energy to his use. Because of the increased development of energy sources in recent years, the time scale is logarithmic, becoming more expanded in the immediate past.

From the dawn of history through ancient and medieval times, man's supply of energy was limited to his own muscles, animal power, and wind and water power. The ultimate source of all this energy, of course, was the sun, which made plants grow food and warmed the earth, causing wind currents and rainfall.

Toward the close of the Middle Ages man discovered that the chemical energy in gunpowder could be transformed into mechanical energy. However, it was not until about 200 years ago that he began to understand fully the equivalence of heat and mechanical energy. With the invention of the steam engine in 1765, a new era began. Coal, and later oil and gas — fossil fuels which the sun had stored in ages past — were discovered. These, it seemed, provided man with limitless supplies of energy to do his work.

But after the invention of the electric dynamo and the gasoline engine, people began to use these new sources of energy so widely that the supplies of fossil fuels seemed to be facing imminent exhaustion. In the years preceding World War II the outlook was not promising. Man's ultimate source of energy was still the sun, and its stored energy was being used faster than it was being replaced.

It now appears that man's eternal curiosity, directed to scientific discovery, may save him from this predicament. Early in this century Albert Einstein had proposed the now famous equation $E=MC^2$, postulating the equivalence of energy and matter; but for many years no one had found a way of actually transforming matter into energy.

Then, in 1939, came the discovery of atomic fission, making it possible to convert some of the mass in the nuclei of atoms into energy. In 1942 the first atomic reactor was put into operation, and the development of atomic power became a practical possibility.

In 1952, the first atomic fusion explosion was brought about with a release of energy several hundred times as great as in the first A-bomb. Now, for the first time, man was able to duplicate the process by which energy is produced in the sun. The next problem he must solve is to control the energy from atomic fusion so that it may be used to drive ships and run electric power plants as is now done with energy from atomic fission.

Plastics

Each year the use of plastics in the home and in industry increases. The

ease of processing as well as the performance of these materials add to their utilization in many diverse applications. Plastics are made by uniting many small chemical units, known as monomers, into a long chain or network structure which is called the polymer. The chemical nature of the monomer and the structural arrangement of the polymer chains determine the physical and chemical properties of the plastic material which can be shaped and molded into intricate forms.

The National Bureau of Standards cooperates in the development of standards and specifications for these materials, of which there are potentially an almost unlimited number. It also devises methods for determining the properties of these new materials and investigates the basic mechanisms responsible for the properties. For example, the mechanisms by which plastics break down on exposure to sunlight, heat, oxygen, moisture, and nuclear radiation are studied to determine the relationship between chemical structure and durability.

Textiles

One of the demands made on fibrous materials used in equipment for industry, public safety, and national defense is the ability to withstand very high-speed impacts. For example, aircraft landing shock must be absorbed in part by textile tire cords. Similarly, impact forces must also be withstood by automobile and truck tire cords.

Another example is the thread used in industrial sewing which must stitch efficiently without breaking under strains repeated 5,000 times per minute. Parachute harnesses, webbing, and shroud lines must take the brunt of high impact forces of opening shock after pilot ejection from high-speed airplanes. Still another example is the flexible body armor that must protect military personnel from exploding shell fragments.

As its part in meeting this problem, the Bureau is assisting industry and Government to solve the basic technical and scientific difficulties in the development, production, and establishment of specifications for fibrous materials. Special precision equipment, utilizing high speed photography, has been built for measuring the properties of fibers, yarns, and fabrics under shock loading.

Numbers, Tables, Answers

The interpretation of many scientific experiments and the solution of engineering and administrative research problems often require extensive calculations. In fact, some problems are so large that they can be efficiently solved only on high-speed computers.

The Bureau maintains a centralized computing facility equipped with the most up-to-date calculating equipment available. This facility serves the needs of the Bureau's own diverse research programs and supplements the facilities of other Government agencies and Government contractors.

An historical presentation showed the significant progress in the development of computing equipment. The earliest digital computer, the abacus, stands in contrast to the present-day electronic digital high-speed computing machine, which combines a vast number of simple operations into a complex high-speed sequence and thus

turns out the answers to many difficult computational and statistical problems. The functions of the Bureau in this area are illustrated by samples of published mathematical tables and by charts of problems solved on these machines.

Volts, Ohms, Amperes

Measurement is vital to the 30-billion-dollar yearly sale of electric energy and equipment. For example, it assures the householder of the accuracy of the electric meter on which his monthly bills are based, and it enables manufacturers to make accurate resistors and coils for use in television sets.

Such measurement is based on the fundamental electrical standards which the Bureau has established and maintained and uses to calibrate master standards for universities, private laboratories, manufacturers, utilities, and regulatory agencies.

The basic standards are known to a few parts in a million; an accuracy of about 3 parts in ten thousand (0.03%) is achieved in the Bureau's standard watthour meter by which the master standards of the public utility commissions and power companies are calibrated. In turn their measurements are made to about 0.1 percent so that the accuracy of the meter in your home is better than 1 part in a hundred. Many other kinds of standards are needed to meet the requirements of modern technology for measuring power, voltage, current, resistance, and other electrical quantities.

Spectrochemical Analysis

Any material when vaporized in an electric arc or spark gives off light whose wavelengths are characteristic of the chemical elements present. When this light is passed into a spectrograph, the wavelengths are spread apart into the familiar rainbow colors known as a spectrum. By observing which wavelengths are present, one can learn which elements, such as iron, manganese, and copper the material contains. The brightness or intensity of spectral lines, relative to intensities obtained from standard samples, tells how much of each element is present. Spectrometric analysis can be made on samples of almost any size or form, from microscopic particles to massive pieces or solutions. Examples of the standard samples were shown and their use was described.

A recent development in this field is the use of the X-ray spectrum as a means of making more precise analyses, particularly for complex alloys such as those used in jet aircraft and rockets. A new X-ray spectrometer demonstrated how the determination of seven elements is made in a stainless steel sample in about one minute.

Research Instruments

Every scientific laboratory must have its instrument shop. Because the National Bureau of Standards is involved in the most careful experimentation and measurement, its instrument shop is called on to produce equipment of the highest quality and precision.

Moreover, to meet the exacting demands of the Bureau's extensive and diverse research programs, its skilled instrument makers must have at their command the full range of techniques

required in all branches of the physical sciences and engineering.

One of the interesting methods which can be seen in operation at the NBS instrument shop is the modern technique of glass-blowing, including the use of the new glass-blowing lathes.

For measuring the accuracy of machined parts, an array of advanced equipment is used — for example, the Probograph, a three dimensional electromechanical measuring machine.

Among the applications of recent advances in science to the art of the instrument builder is the process of ultrasonic cavitation, which makes use of sound waves above the audible range for high-speed precision drilling.

Crystals and Corrosion

Wherever metals are used, corrosion presents its threat to economy and efficiency. Although much has already been done to control its damaging effects, corrosion is still estimated to cost this country more than 5 billion dollars annually.

The Bureau's contribution to solving this problem consists principally of attempts to determine the fundamental causes of corrosion and special studies of the corrosion resistance of specific alloys and types of alloys. Of special interest is the influence of metal structure on tarnishing and attack by acids and alkalies. Metals are generally made up of many small crystals — small units within which the atoms are arranged in perfectly ordered fashion. Instead of working with ordinary metals whose crystals are jumbled up haphazardly, the Bureau is studying large single crystals.

A. G. McNish, *Consultant to the Director of the National Bureau of Standards demonstrates the combustion heat of 100 proof ethyl alcohol.*

It is found that when an aluminum single crystal is corroded, different symmetrical shapes develop depending on whether the attacking substance is acid or alkali. It is also found that when a copper single crystal is heated in oxygen, beautiful symmetric patterns of tarnish colors are formed on its surface. Thus, the results indicate that degree of corrosion depends on atomic arrangement on the surface.

Flames and Their Light

Some of first great advances in science are connected with the study of combustion. Today scientists are pushing this study down to its finer details and are investigating the atomic and molecular changes that give rise to flames.

➤ IN THE FIRST FILMING *of this phenomenon to be publicly exhibited, Dr. R. D. Huntoon, Associate Director for Physics at the National Bureau of Standards, demonstrates the production of free radicals and their storage at low temperatures.*

The Bureau is interested in this problem because of the need to control the rate of burning and amount of energy released in the various flames found in such equipment as rockets and internal combustion engines.

This requires a thorough knowledge of the mechanism of combustion, and makes it necessary to develop ways to measure temperatures of flames that are too hot for ordinary thermometers.

One way to study flames is to analyze the light they give off. This tells what molecules are present in the flame, and gives information about how energy is released in it.

A very useful technique is to study the light from flames at very low pressures such as a rocket encounters at high altitudes. Under such conditions the processes that generate light can be studied in greater detail, and reactions with atoms normally present 60 miles up in the atmosphere can be reproduced.

Automotive Fuels

An important factor in the "matching" of engines and fuels is the octane

number. Because of the trend toward higher-compression engines in the automotive industry, as well as aviation requirements, high octane numbers are increasingly important.

The National Standards for measuring octane number are two hydrocarbons (normal heptane and isooctane) which were synthesized and purified to a high degree in NBS laboratories.

Ultimately, the quality of all the gasoline sold, at the rate of about 2 million gallons per hour, is referred to the National Standard.

As the continuing development of engines and fuels brings new problems, researches are conducted to improve the precision of measurement, raise the quality of the fuel standards, and to study the mechanism of fuel combustion as well as the effects of such variables as altitude, temperature, and humidity.

The Bureau has played an important part in the study of the relationship between the knocking characteristics of gasoline constituents and their molecular structure. These studies provide a background of information useful in maintaining the standards.

Parity in Nuclear Physics

"Parity" is a concept of theoretical physics that deals with mirror reflection. This exhibit illustrates the meaning of parity by showing what happens to two common objects when they are reflected in a mirror. We shall say, for instance, that a sphere is associated with a "definite parity" because it is indistinguishable from its image. On the other hand, since we can easily tell a screw from its image, we shall say that a screw is not associated with a definite parity.

For the last three decades theoretical physicists have assumed that all the basic particles which compose the nuclei of atoms were "sphere-like", that is, they had definite parity. Furthermore, every process involving these particles was assumed to be indistinguishable from its mirror image. Recently these assumptions were challenged by the theoretical physicists T. D. Lee of Columbia University and C. N. Yang of the Institute for Advanced Studies at Princeton, who also suggested several experiments to prove or disprove their contention. The National Bureau of Standards undertook one of these experiments in collaboration with Columbia and results were obtained which verified the Lee-Yang hypothesis. The exhibit explained the Bureau experiment in terms of the sphere and screw models, showing how nature has given "screw-like" properties to certain nuclear reactions.

The technique of recording television signals on two-inch wide magnetic tape has recently been extended to include the recording of color TV signals.

The relatively rarity of cancer, rather than its prevalence, is a major reason for the failure of science to produce a cancer cure.

Semiconductor devices are used in land mine detectors for the Army with resultant reduction in size and weight and increased sensitivity.

Heat Resistant Plastics Revealed

➤ ROCKETS soon may be brought back from space as a matter of routine, thanks to a revolutionary family of plastics recently revealed.

The new materials which are produced and formed like plastics, but incorporate the strength of metals and heat resistance of ceramics, are able to function "in areas where all other known materials break down," a joint conference in Montreal of the American Institute of Chemical Engineers and the Chemical Institute of Canada was told.

"Haveg compounds," as the new family of materials is called, are not metals, plastics or ceramics, but a "combination developed for high temperature operation," John H. Lux, Haveg Industries, Inc., Wilmington, Del., and Norbert H. Noland, Reinhold Engineering and Plastics Co., Norwalk, Calif., reported.

Reinforced Plastics

A combination of composition and unique mechanism of reaction while being exposed to high temperatures makes the materials functional at temperatures up to 12,000 degrees Fahrenheit, the chemical engineers said.

The new materials are of a type called "reinforced plastics" and basically are similar to many familiar products made of plastic reinforced with other materials.

Haveg compounds consist of inorganic silicates similar to glass, held together with an organic plastic binder, the engineers reported. Consequently, the compounds can be produced and molded like plastics, but assume the rigidity and strength of glass.

Some Parts Produced

When a nose cone or missile fin made of Haveg compounds encounters extremely high temperatures, a chemical reaction takes place between the organic plastic and the inorganic silicates, producing a new material that actually reflects away most of the heat, and has a high resistance to corrosion.

Haveg-based nose cones, motor cases, insulators and jet vanes capable of withstanding temperatures near 6,000 degrees Fahrenheit already are in production. Newer compounds that will withstand reentry runs of 20 seconds at 12,000 degrees Fahrenheit have been developed, the authors reported.

Salt Kills Oysters' Enemies

➤ COMMON SALT may soon turn the tide in the huge losses suffered by oyster growers because of the starfish, sponges and "drills" that prey on oysters.

Marine biologists at the U. S. Bureau of Commercial Fisheries' Milford, Conn., laboratory have found that a saturated salt solution can be 100% effective in killing the oysters' enemies. Most methods, including some 2,000 different chemicals tested, endanger the oysters.

Much Work Ahead For Scientists

New Frontiers in Science in 1958

by Watson Davis

Excerpts from a talk at Conference on Technical and Scientific Writing Michigan State University, East Lansing, Mich., April 15, 1958

▶ We have our sights set upon the moon, although the morbid fears of the world are centered upon thermonuclear bombs poised over mankind.

Science and technology have brought civilization to such a state that we can go on to greater achievements. We can unravel some of the universal mysteries. We can, if we are allowed, perfect the mechanical arrangements of our lives so that they are more effective and unobtrusive. We can make people healthier, wealthier, and perhaps even wiser.

Atomic or biological war can bring a new dark age for the world that would pale into insignificant history the great plagues of past ages.

Assuming that the dangers of destruction can be avoided, there are gigantic tasks ahead for science and technology. The successes of the past make us confident that we can continue the progress, given peace, public understanding and a nurturing of our brains.

Compiling timetables for the science of the future is risky and hazardous, but here are guesses at what may happen:

About a decade hence (1970):

1. *Cures* for some of the most prevalent kinds of *cancer*, whether through chemotherapeutics, or prevention arising out of better understanding of metabolic processes.

2. The *conquest* of more *virus diseases*, including the so-called common colds, either through vaccination or drugs.

3. *Treatments* for more of the *mental diseases* that will rescue and return to usefulness more of those psychotically ill.

4. *Power from atomic fusion*, the hydrogen bomb reactions.

5. *Harnessing of the sun's energy* through artificial photosynthesis that beats the green leaf at its own game.

6. *Exploration of the moon* by unmanned, but information-gathering rockets, and similar space probes towards Mars and Venus.

7. More major *mechanizations of industrial processes*, together with development of economic devices to keep employment at an optimum level.

8. More universal *assaying of human abilities* and the enhancement of educational opportunity that will more nearly utilize the talent of all the world's population.

9. *International television* through signals relayed by reflection from special TV satellites.

10. Development and application of a simple and safe *birth control method* that could modify the world's population explosion.

More distant in the future, some

perhaps by 2000, there are these possibilities:

1. Discovery and harnessing of unknown *forces within the atomic nucleus,* giving new sources of energy, transmutations of matter, and new knowledge of the possible ultimates of the physical universe.

2. *Exploration of the cosmos* by new astronomical methods that will delineate its size in time and space, whether the universe has boundaries, whence it came, whither it is going, how long it will last, and its operation and control.

3. Approaches to the *postponement of individual death,* through understanding and remedial treatment of the degenerative diseases and by the prolongation of life through nutritional, biological and other means.

4. Understanding of the *nature of life,* through biophysical and biochemical exploration of the functions and mechanisms peculiar to animate matter.

5. The *creation of life* from inanimate materials, duplicating the genesis of primordial slime in the opening eons of the living earth.

6. Attempts to discover whether some of the probable hundred million *planets of other stars* have life or conditions for life like that on earth.

7. Development of new *methods of rocket propulsion* that will make interstellar travel more practical.

8. Development of *standard synthetic diets* easily assimilated that will supply the calories and protective factors for optimum mental and physiological existence, possibly available to all as a public utility.

9. *Universal communication facilities* so that sight and sound will link on demand any individuals anywhere on earth, coupled with world-wide TV channels for music, education, information, public meetings and ceremonies, etc.

10. Development of *artificial intelligence machines,* that will do things people do now — write letters, do bookkeeping, translate languages, file and retrieve information, teach students individually, plan and operate industrial processes, cook, serve meals and clean houses, drive automobiles and airplanes, etc.

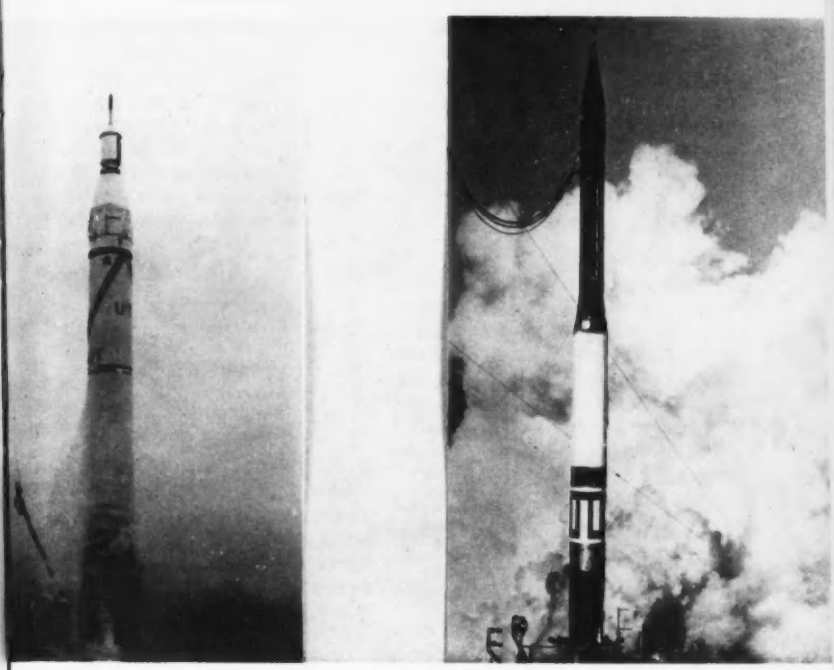
Explorer III Gathers Valuable Data

➤ INFORMATION considerably more valuable than expected is being gathered by Explorer III because of its unplanned, close-to-earth orbit.

The satellite, officially named 1958 Gamma, is "completely fulfilling" its scientific mission, the National Academy of Sciences IGY committee reported. The "tremendous sweep" of the orbit, varying from 117 to 1740 miles above the earth, is "splendid" for cosmic ray research.

The information radioed back from Explorer III almost ties into the cosmic ray data from vertical rocket firings. The transmitters and tape recorder are working properly, according to Dr. James A. Van Allen, member of the IGY committee's technical panel on the earth satellite program.

Information on temperatures and micrometeorites, as well as on cosmic rays, is being continuously telemetered to earth by the satellite's low-power transmitter.



➤ SPACE AGE ART. *Gaudy designs on rockets are carefully planned to yield valuable scientific information. The Jupiter-C Explorer satellite-launching rocket in the Army photograph at the left carries bands and spiral stripes from which engineers can compute its rate of rotation, pitch and yaw. Different designs perform the same function on the Vanguard satellite vehicle shown in the Navy photograph at the right. The second stage is unpainted stainless steel, but appears white due to a frost coating caused by extremely cold liquid oxygen carried in that section.*

Missile and Rocket Paints

by DAVID PURSGLOVE

➤ THOSE BLACK and colored stripes, squares and odd geometrical shapes you see in pictures of rockets fired at Cape Canaveral or other sites are not just decoration to make the rocket look good, or even to help identify it.

Nor are the strange markings there to help track the missile. It is easier to track and photograph a solid white missile.

Viewed only as artistic designs, the strange markings have no significance whatsoever. However, for scientific purposes, they have been very carefully planned. Although there is no esthetic meaning to the designs, each enables scientists and engineers to gain valuable information from a missile in flight.

Pitch and Yaw

The black bands painted around a rocket's girth and the long straight or spiraling stripes are motion picture photographic reference points from which missilemen can compute the rocket's rate of rotation, its pitch and yaw, angle of flight at a specified point in flight, and even deviation from predicted course.

Although most of the stripes are black, some are colored for greater clarity in color shots of the shoots.

Occasionally a rocket will carry small, round or square patches of paint. These are protective paints either to resist corrosion at sensitive points, or to protect delicate instruments inside the rocket at that point from excessive heat.

Since, in the case of large missiles, about ten pounds of propellant are needed to move one pound of paint, paints generally are used sparingly. Most large missiles either remain unpainted, or are protected with a very thin coat of lightweight lacquer.

Anti-corrosion

However, protective paints do guard against corrosion and high temperatures to some extent, although their advantages sometimes are offset by their weight. Small, short-range missiles in which weight is not such an important factor usually are painted. Sometimes paint is used to make the missile harder to see.

Test-firing models of the Army's Redstone may be marked distinctively for scientific purposes, but operational models now in the hands of our overseas troops are painted olive drab to help prevent their detection by reconnaissance forces or aircraft.

The Navy's Vanguard satellite vehicle is basically olive drab, except for the unpainted stainless steel second stage. There are black reference lines on the first stage and near the top of the second stage. In launching site pictures the second stage usually looks white instead of silvery. This is the stage that holds containers of extremely cold liquid oxygen which causes that stage to become coated with frost.

Vanguard officials once considered painting the entire vehicle white as an aid to photographers. However, as one official told Science Service, "the photographers bowed to the scientists' information requirements."

Vanguard, incidentally, carries no letter or numerical marking. Neither the words "Navy" nor "Martin" (the builder) appear anywhere on the rocket.

The highly polished spherical satellite is "glass coated" with a very thin coat of silicon monoxide for heat protection by reflection.

The nose cone of the Vanguard launching vehicle is black "for no particular reason."

Zirconium Oxide Paint

However, nose cones of Jupiter-C rockets used to launch the Army Explorer series satellites use a special paint combined with carefully planned art work to help control internal temperature.

Jupiter-C nose cones carry black and white stripes, the width and spacing of which are governed by the predicted rate of spin. Black areas absorb heat and white areas reflect heat. As these areas spin, like stripes that might be painted on an artillery shell, the internal nose cone temperature is held within a desirable range as the rocket passes from the high temperatures of early stage air friction to the extremes of heat and cold encountered in the rocket's orbital path.

Temperature control is aided by the use of a special zirconium oxide paint for some of the stripes. This paint is compounded to absorb and release heat under various flight environment conditions.

Some of the most important painted designs in our missile program are on the inside of rockets where they never are seen by the public. These are stripes and patches of temperature-sensitive paints that change color permanently upon exposure to varying temperature ranges.

Temperature-sensitive Paints

These are the same paints that are used to record variations in temperature along a machine gun barrel or to indicate where a furnace is leaking heat.

These paints reduce the weight and cost of recoverable re-entry missiles such as the X-17 and Jupiter-A by eliminating many thermocouples previously used to record interior temperatures. Thermocouples still are used at points requiring very exact temperature measurements.

Recently Science Service revealed that Air Force scientists have developed a radically new type of paint that may cause our military leaders to change completely their thinking about our defenses against bomber raids and missile attacks.

Anti-radar Paints

Wright Air Development Command scientists have developed and are now rapidly perfecting an anti-radar paint that would greatly reduce the chances of radar detection of planes and missiles coated with the new material.

If necessary, the paints as they now exist could be used effectively, Defense Department officials told Science Service. However, before they are put into routine service, their weight must be reduced and their screening effectiveness and resistance to weather must be improved.

Although military leaders are pleased with the new paints and regard them as potential blessings to American air power, many officials frankly admit they are worried about the more far-reaching implications.

In view of the Soviet Union's recent technological advances, "there is every reason to believe the Russians are working on such paints and they just might even be ahead of us," one authority said.

"If the Reds perfect anti-radar paints, what will happen to our Distant Early Warning system in Canada, and Texas tower radar posts in the Atlantic?"

He partly answered his own question by hastening to add that existing and contemplated anti-radar paints even at their best could not completely hide a plane or missile from radar, but could only reduce the chances of discovery.

Anti-radar protective coatings developed so far can be called paints

only insofar as they can be spread on an aircraft or missile surface instead of being bolted on in the manner of early materials designed to fool radar. Actually, the paints are heavy, very thick coatings.

Just what is in the coatings has not been revealed, but it is known that some materials used inside radar testing rooms are made of horsehair impregnated with carbon or of rubber bonded to brass and ceramics. Their function is to absorb radar waves — electromagnetic energy — instead of allowing it to bounce back to the radar station.

Energy-sensitive Chemicals

This can be accomplished by any material that causes wave loss through absorption. However, a more sophisticated approach is believed to involve conversion of the waves by chemicals similar to those in photographic film emulsions.

Photosensitive chemicals convert light energy into chemical energy. Chemicals believed to be under consideration for improved anti-radar paints would convert radar's electromagnetic energy into chemical energy on an aircraft or missile surface. Consequently there would no longer be any electromagnetic energy available to bounce back to the waiting radar station and reveal the object's presence.

One Pentagon official hinted that this new development may cause us to change our entire plan of work on an anti-missile missile. Although there are several systems that can spot, track and then pursue an invading missile, radar at present is the most advanced and probably the easiest to use in an anti-missile system.

If enemy missiles were painted with an anti-radar paint, our anti-missile missiles, as now planned, would be rendered useless. Our own Defense Department already plans to paint our missiles with the new materials if the Russians base their anti-missile missiles on radar.

Although Wright Air Development Command scientists are hard at work to improve anti-radar paints, the ones that already exist would be satisfactory for emergency purposes. Weight is not such a critical factor when one remembers that only certain parts of a bomber need to be coated to cut down radar detection considerably.

New Fluorinated Hydrocarbon Anesthetic

➤ A NEW and potent non-explosive anesthetic named Fluothane has been introduced to aid U. S. surgery.

A fluorinated hydrocarbon first synthesized in England in 1951 as trifluorobromchlorethane, it is said to have many advantagees over ether and chloroform. It has been successfully used in 20,000 clinical trials in England, Canada and the U. S. since 1956.

According to Dr. John B. Jewell, medical director of Ayerst Laboratories which introduced the new anesthetic, it has been used successfully in almost all known operative procedures in patients of all ages and conditions.

Fluothane has exhibited essentially no adverse side effects such as nausea or vomiting, and emergence from the anesthetic is very rapid. Because of its non-explosive nature, Fluothane will permit wider use of modern electrical equipment in advanced operative procedures.

Outline Help for Young Scientists

Science Experiments Discover Ability

➤ THE GREAT nation-wide experimental interest in science in the nation's schools is giving hundreds of thousands of students their first opportunity to discover their science abilities.

Science fairs in which students show their "projects" are held in thousands of schools.

This participation in projects, usually resulting in an exhibit that can be shown at a science fair, reinforces science teaching and creates demand for better science teaching. The science projects done in schools — and in the homes of America with the aid of understanding parents — are first steps in discovering the intellectual and emotional rewards of science activity. In this way scientists are nurtured. Effective interest and participation of young people, some even still in grade school and even kindergarten and nursery school, leads to the kind of early accomplishment in science that will provide the scientific sinews of our nation's future.

18,000 Science Clubs

Science Service, with the support of the National Science Foundation and other agencies, is engaged in spreading the science youth program throughout the land. There are now some 18,000 science clubs affiliated with Science Service. There are thousands of science fairs in the nation's secondary schools, the best exhibits of which will go to some 160 local or regional fairs covering the nation. These fairs each send their two top finalists to the National Science Fair, a Science Service activity.

For 17 years the Science Talent Search for the Westinghouse Scholarships and Awards has provided an incentive to science achievement to those about to enter college.

Just a Start

There is much more to be done and, thanks in part to the awakening that followed the sputniks, there is promise that more will be done, by industry, by government, and especially at the local level, reached by science clubs and the science fairs.

The embryo scientists and their fellows in school need more with which to work:

They need the support of more and better teachers, more adequately paid. Science teachers should be treated as well as athletic coaches.

They need more opportunity to perform experiments and do original projects. Inexpensive experimental kits, pioneered by Science Service, need more extensive availability. Young people need to get their hands dirty and their minds disturbed by actually playing science, not just reading about it or watching TV or teachers perform experiments.

They need more information, "hard" literature, and current reports of what scientists are doing, and what are the problems of the future. In this, industry can be effective, through sponsoring inexpensive books and pamphlets. They need to have their searching and sometimes troublesome queries answered.

They need summer jobs that will allow them to aid actual research as

they gain essential experience in the laboratories.

They need to be treated as maturing scientists of the future.

We need to devise new methods of speeding science education and participation in science by youth.

International Interest

America must also share its enthusiasm and its aid to scientific youth with the rest of the world. No export of America will be so gladly received in other parts of the world as our science education "know-how." Already some of the methods developed are taking hold in nations like Japan, Thailand, the Philippines, etc.

The other functions of Science Service as the institution for the popularization of science, operating since 1921, are important to the general advancement of our culture, as well as backgrounding the science youth activities.

Science Service's service to newspapers, by wire and mail daily, was effective in causing the press of the nation to treat science with as much seriousness and clarity as politics, sport and financial news. Science Service continues to be the standard byline in science reporting, reaching 19% of the daily newspaper circulation of America — some 10,000,000 circulation — and serving some 28% of the population. Thus the original activity of Science Service is strong and important.

Our services to individuals — SCIENCE NEWS LETTER, CHEMISTRY magazine, THINGS of science experimental kits — serve important functions.

Science Service has also pioneered in origin of microfilm, new methods of publication and the international language, Interlingua.

Science Service attempts to participate in the useful, the novel and the practical activities to tell the world about science.

Summer CHEMISTRY Book Announced

➤ IN LIEU of the May issue of CHEMISTRY subscribers will be sent during the summer THE CHEMICAL ELEMENTS, a book issued first in 1952, out of print for some months. Originally THE CHEMICAL ELEMENTS was published as a special issue of CHEMISTRY. THE CHEMICAL ELEMENTS was written by the late Helen Miles Davis, then editor of CHEMISTRY, and it has now been revised with the aid of Dr. Glenn T. Seaborg, Nobelist and discoverer of transuranium elements. This book will be made available in a paper bound edition at 50 cents, and subscribers are invited to order extra copie at the rate of $5 for 10 copies to one address, postage prepaid. For additional extra single copies, add 5 cents postage. Address: Science Service, 1719 N St., N.W., Washington 6, D.C.

Metallurgical Bacteria Go Commercial

by Howard Simons

➤ Metal-loving bacteria are being put to work by the Kennecott Copper Corporation extracting a variety of metals that would normally be lost as waste.

The bacteria, which live and breed in acid mine waters, have demonstrated that they are far better extractors of metals than processes presently used.

Kennecott scientists are currently tailor-breeding the bacteria for specific jobs. One strain of bacteria, for example, could not survive in solutions containing more than 150 parts of zinc per million. Successive breeding, however, has produced bacteria that can now thrive in a solution of 17,000 parts of zinc per million. The same tailoring has developed particular strains of the bacteria for aluminum, calcium, magnesium, manganese and molybdenum.

Natural Redox Systems

Historically, researchers have known for some time that iron oxidizing, self-sustaining bacteria dwelled happily in the coal mine acid waters of the eastern United States. They knew too that these bacteria had the ability to oxidize ferrous iron to ferric iron at a rate considerably greater than would be due to the atmosphere alone.

Thiobacillus ferrooxidans has been the scientific name proposed for these microscopic metalworkers.

More recently, the U. S. Bureau of Mines reported that four of its laboratories are conducting small-scale research on the role microbes can play in increasing metal production. (See CHEMISTRY, March 1958, p. 39.)

Now, a team of Kennecott scientists have received a patent on an invention employing the use of iron oxidizing bacteria in the cyclic leaching of sulfide minerals.

This was made possible when the team discovered similar strains of the bacteria present in eastern U. S. coal mine waters in acid mine waters in Utah and New Mexico.

Recovery From Waste

Conventionally waste water from copper mines has been percolated and repercolated through ore waste dumps to leach out whatever copper values might be contained in the waste. With the bacteria inoculated into the ferric sulfate-sulfuric acid leaching agent, however, the amount of copper recovered increases substantially.

The team points out that several factors need be considered in using bacteria to leach out metals from waste material. One factor, for example, is that redwood tanks, employed by many mining and milling operators, release a bactericide or bacteria killing agent. Bacteria, however, can be bred to tolerate this situation.

The scientists who invented the bacteria extraction method are Stuart R. Zimmerley, Dean G. Wilson and John D. Prater of Salt Lake City, Utah.

Gigaton Bombs Among Future Weapons

➤ WHETHER OR NOT the Russian announcement of the stopping of nuclear tests is a "political Pearl Harbor," the necessity of doing something about the arms race is emphasized by a report to the National Planning Association by Col. Richard S. Leghorn, expert on aerial reconnaissance, now president of ITEK Corp.

Estimating the world's arms situation in 1970, here is what is foreseen:

Between now and 1970, less time than since the end of World War II, the world will spend almost two trillion dollars (two thousand billion dollars) on armament.

The United States is devoting 50% of its technological resources to the arms race, Russia, second technological country, is devoting an even higher percentage, and western Europe is spending an even higher percentage.

Billions of Tons of TNT

There is talk of "gigaton" weapons representing the equivalent of billions of tons of TNT, but the military usefulness of such weapons is doubtful, since the trend is to atomic and hydrogen weapons small enough for fighter aircraft, missiles and artillery.

Rocket launchings will be made from underground sites, mobile platforms on the ground, on and under the sea and from aircraft.

Rockets will launch bombs faster than ever, with the time from the instant of command to megaton explosions one to 6,000 miles away running from ten minutes to about half an hour.

Without arms control, modern weapons will come into possession of more and more nations, some of which may be irresponsible or even fanatical.

Reliable physical inspection for possession of nuclear warheads is already impractical.

Tests Should Continue

Col. Leghorn, separating the nuclear test issue from other disarmament steps, suggested that the U. S. should continue testing to develop nuclear dynamite for peaceful purposes and so-called clean bombs, that tests should be registered with the UN with other nations invited, and that nuclear dynamite be made available to any world user approved by the UN. The U. S. would under this plan suspend all tests of "dirty" weapons at the end of 1958.

The suspension would be continued if before the end of 1959 a few dozen mutual inspection stations were established, and if before the end of 1960 there is a full international agreement for a world-wide inspection grid.

The U. S. under his suggestion would convert most of its "dirty" weapon stockpile into a "clean" stockpile.

He also suggested a UN arms information and research agency to develop the tools of a world security system.

Argon, the most abundant of the rare gases, makes up almost one percent of the atmosphere.

Argon is used to fill fluorescent lamps.

For The Home Lab:

The Benzoin Condensation

by Burton L. Hawk

▶ When benzaldehyde is heated with alcohol in the presence of an alkali cyanide, it undergoes dimolecular condensation to the ketone, *benzoin*. This reaction is known as the "benzoin condensation", or, when applied to other aldehydes, the "aldol condensation."

The reaction of benzaldehyde was discovered by accident. In earlier days, benzaldehyde was extracted from amygdalin and purified with alkali. The crude amygdalin also contained some hydrogen cyanide which was converted to sodium cyanide by the alkali. This product catalyzed the formation of benzoin. Hence, along with the benzaldehyde, the chemists found themselves with a supply of benzoin. The chemical reaction was first recognized by Liebig in 1832. It is now known that the cyanide serves as an essential catalyst for the reaction.

Preparation of Benzoin

The success of this preparation depends much upon the freshness and purity of the benzaldehyde. If your reagent is not strictly fresh, it is necessary to distill it before using. In doing this, it is wise to add small pieces of glass rod to the liquid to prevent "bumping" and provide more even boiling.

Place 10 cc. of freshly distilled benzaldehyde in a 125-cc. flask. Add 25 cc. of ethyl alcohol and 1 gram of potassium cyanide (CAUTION! *Cyanides are extremely poisonous! You must use extreme care in handling. Do not breathe any of the vapors; do not allow to come in contact with your skin. Wash your hands immediately after using. Wash all containers with large quantities of water after experimenting).* Fit the flask with a one-hole stopper and insert a 3-ft. length of glass tubing in the stopper. This arrangement will serve as a reflux and will allow you to boil the solution with a minimum of evaporation loss. Bring the solution to boiling and allow it to continue boiling gently for approximately 35 minutes.

Upon cooling, the benzoin separates out as pale yellow crystals. Carefully filter off the crystals and allow to dry. Redissolve the crystals in ethyl alcohol. After allowing the alcohol to evaporate, the purified crystals remaining should be nearly colorless.

Like the *a*-hydroxy ketones of the sugar series, benzoin will reduce Fehling's solution. To demonstrate, dissolve a few crystals of benzoin in a small quantity of alcohol. Add Fehling's solution and warm. (NOTE: Fehling's solution consists of two solutions which are kept separate until ready for use. They are then mixed in equal volume and added to the solution to be tested. One solution is prepared by dissolving 1.5 grams of copper sulfate in 50 cc. of water. The other solution is prepared by dissolving 8.5 grams of sodium potassium tartrate (Rochelle Salt) in 10 cc. of

warm water; adding a solution of 2.5 grams sodium hydroxide in 10 cc. of water and diluting the mixture with 30 cc. of water).

Oxidation to Benzil

The oxidation of benzoin produces benzil, a yellow crystalline substance. It has no specific use in itself but is used as an intermediary in the synthesis of many organic compounds. So, I suppose, if we want to be practical there is no reason why you should take time to prepare it. However, for our impractical fans, we proceed as follows:

Place 3 grams of benzoin in a small flask and add 12 cc. of concentrated nitric acid. Heat the mixture until evolution of the brown fumes ceases. This may require as long as an hour. Be sure not to breathe the brown fumes. It is best to perform this experiment in well-ventilated surroundings. Pour the mixture into a beaker containing 100 cc. of cold water, stirring thoroughly. The benzil will precipitate out and can be removed by filtration. Dissolve the crystals in hot ethyl alcohol and recrystallize.

The benzoin condensation reactions may be applied to other aldehydes as well. For example, with acetaldehyde the product is an aldehyde-alcohol known as *aldol*. This product is used in perfumes, in metallurgy, and for the manufacture of rubber vulcanizers. Do not attempt to prepare this product as instructed with benzaldehyde, as the reaction must be modified to suit the individual aldehyde.

Space Travel and Science Education

➤ TEACHING our young science students the theories behind rockets is more important than encouraging them to build and fire homemade ones, according to Dr. David Woodbridge, assistant director of the Army Ballistic Missile Agency, Redstone Arsenal, Huntsville, Ala.

Now that Russian and American satellites have launched the space age, Dr. Woodbridge told the National Science Teacher's Association in Denver, this country's future mastery of space science must rest on the education of our youth to meet its problems.

Basic conceptions of space, temperature, weight and force must be restudied in the light of new knowledge being transmitted to us from the orbiting satellites. Human biology too, Dr. Woodbridge said, must be studied in the light of new demands upon man in the space age.

Dr. Woodbridge urged the assembled teachers to lead their students by breaking with conventional thinking and replacing it with newer knowledge being gathered from study of space. Original thinking must be encouraged among students if they are to cope with new problems in a new age.

In a plea to encourage the abler students, Dr. Woodbridge warned, that "we cannot teach to the level of the mediocre student or American science will shrivel into mediocrity."

He predicted that whether America will be a first- or second-rate power in the future will be determined in American schools and urged science teachers to rise to the challenge of the times.

√ *Chemistry Quiz* √

Directions: Mark within the parentheses corresponding to the answer you think is *most nearly correct.* Answers are on page 30.

1. All of the following are organic except
   ( ) 1. alcohol
   ( ) 2. aldehyde
   ( ) 3. ketone
   ( ) 4. lanthanum

2. An apparatus, invented in 1911, is used to study the behavior of alpha particles, electrons, positrons, mesons, photons, and the collision of these particles with atoms. The apparatus contains moist air, which is permitted to expand rapidly, permitting condensation, and the trails of water droplets reveal the paths of the rapidly moving subatomic particles. This apparatus is a
   ( ) 1. cloud chamber
   ( ) 2. desiccator
   ( ) 3. pressure chamber
   ( ) 4. vaporizer

3. *Chlordane* is used in
   ( ) 1. dyeing synthetic fabrics
   ( ) 2. exterminating rodents
   ( ) 3. killing insects
   ( ) 4. treating shock

4. Which of the following is *not* a rare earth?
   ( ) 1. hafnium
   ( ) 2. holmium
   ( ) 3. praseodymium
   ( ) 4. samarium

5. Which characteristic of zirconium makes it difficult to obtain?
   ( ) 1. It is too active chemically during extraction from its ore.
   ( ) 2. Its ores are too inactive chemically.
   ( ) 3. Natural ores of zirconium are found only in very inaccessible places.
   ( ) 4. Too low a temperature is required in its extraction from its ore.

These questions have been taken from Science Aptitude Examinations used in previous years as part of the annual Science Talent Search. Complete copies (with answers and norms) of many previous examinations are available at 10c each from Science Service, 1719 N St., N.W., Washington 6, D. C.

Atomic industrial plants of the future will be safer to work in than conventional plants of today, it is predicted.

Pictures Transmitted on Glass Thread

➤ GLASS AND PLASTIC fibers that conduct light may replace photographic lenses and improve some medical instruments, developments in the new science of "fiber optics" at the Armour Research Foundation of Illinois Institute of Technology, Chicago, promise.

A Foundation scientist, Dr. Narinder S. Kapany, said present instruments for viewing inside stomachs are based on a periscope arrangement of lenses and are limited in their fields of view because they are not flexible.

Dr. Kapany said the flexibility of glass or plastic "ropes" allows them to be "navigated along curved channels" within the human body to eliminate "blind regions" and simplify examinations.

The need to insert a light bulb or light-carrying mirrored tube would be eliminated by using coarse fibers to conduct light from an outside source to illuminate the stomach. Fine fibers then would transmit a view of the stomach interior to outside the body for study by physicians. The same system also could be used for medical color photography, he said.

The pick-up and transmission of images by plastic or glass fibers also may be used in photographing TV screens, Dr. Kapany said. Conventional photography suffers from large losses of light. This problem would be overcome by fiber optics. For the same reasons, he said, general color photography may be aided by fiber optics. At present, poorly lighted objects are not good color photography subjects.

One intriguing possible field of application for fiber objects mentioned by Dr. Kapany is in "cryphotography," the coding and decoding of pictures, maps and written matter by photography.

The fibers in a rope could be misaligned or improperly arranged, then used to photograph a map, Dr. Kapany said. The resulting photograph would be unintelligible to any person who might intercept it. However, if the map should reach its destination safely, it would be photographed again, through an identically misaligned fiber rope, and the final print would display the map correctly.

Electron Tube Made in Button Size

➤ ELECTRON TUBES can now be made in button size, although once they were bulky in fragile glass tubes.

The new miniature tubes, still in the laboratory stage, operate at temperatures from 900 to 1,500 degrees Fahrenheit. Their small size results partly from the fact that all heat necessary for operation is provided by their environment.

The experimental models, being built by General Electric Research Laboratory scientists, are shaped like flat disks and measure only one-quarter of an inch in diameter and one-eighth of an inch in thickness. The tubes are made of layers of titanium and a special ceramic.

Specialized Field to Have Intense Treatment

Crystal Chemistry Encyclopedia Planned

▸ The Pennsylvania State University has announced establishment of The Groth Institute to serve as world center for revision of "Chemical Crystallography" — encyclopedia of crystal chemistry and physics.

The Institute will operate within the College of Chemistry and Physics under the direction of Dr. Ray Pepinsky, research professor of physics and director of the X-Ray and Crystal Structures Laboratory. Dr. John A. Sauer, head of the department of physics, will serve as the University's administrative representative.

First Issued by Groth

"Chemical Crystallography" was issued by the German crystal chemist, physicist and mineralogist, Professor Paul Heinrich Ritter von Groth, in the years between 1906 and 1919.

Pointing out that Prof. Groth's compilation of crystal properties still is of tremendous value to natural scientists, Dr. Pepinsky noted that it was conceived before the discovery of x-ray diffraction and crystal structure analysis and therefore contains little information compared to that now available relating crystal structures and chemical and physical properties.

"Discussion of all known relationships of this type, deductions of new relations and the revelation of the most important gap in knowledge in this realm, are among the first purposes of the new encyclopedia," Dr. Pepinsky said. "Advances in older and development of many entirely new types of physical measurements since the first compilation and consequent accumulation of data clearly necessitate this revision."

Will Take Ten Years

The first revision of the encyclopedia is expected to take at least 10 years. The first two years will be concerned almost entirely with data collection. Since information on crystals is being collected so rapidly, it is anticipated that further revisions will be required continually. The publication of these revisions will be simplified greatly by the processes of automatic data handling and printing.

"A notable and essential feature of the encyclopedia will be the use of IBM punched card recording, storage and handling of abstracted data and the use of high speed calculating machines for all necessary computations and combinations of those data," Dr. Pepinsky said. "Without such methods, the amount of data to be handled would be unmanageable. It was largely this fact that discouraged earlier revision."

Dr. Vladimir Vand, associate professor of physics, and a member of the laboratory staff, already is supervising data recording and machine computations.

Many Fields Represented

Dr. Pepinsky will serve as editor-in-chief of the encyclopedia. The editorial board will consist of chemists, physicists, mineralogists and metallographers from all parts of the world.

An advisory board will be chosen, selected from editors of special compilations of chemical, physical and mineralogical data. A board of trustees, composed of representatives from supporting agencies, also will be selected.

A conference of American editors, contributors and other interested crystallographers was scheduled at the University for April 25 and 26 under the auspices of the Solid State Sciences Division of the Air Force Office of Scientific Research.

Plans for the Institute, which have been under consideration for several years, were furthered by a conference of leading crystallographers at Harvard University in 1956; two trips to Europe by Dr. Pepinsky in 1957; and discussions at the Congress of the International Union of Crystallography in Montreal last June.

Dr. Pepinsky will go to Europe in June under a Guggenheim Fellowship and a Smith-Mundt grant from the U. S. State Department. There he will complete the organization of the Institute's editorial board. He also will make arrangements for contributions from many laboratories and will participate in conferences concerning the newly-developed punch card data handling methods. The University has granted him a leave of absence for this purpose.

Dr. Pepinsky has made many important contributions in x-ray and neutron crystal analysis, in solid-state chemistry and physics, and in the field of high-speed computing machines and methods. He has pioneered in low temperature x-ray and optical investigations of crystals and in the development of automatic machines for collection of optical data on crystal form, and for automatic collections of x-ray and neutron diffraction data for crystal structure analyses. These machines will greatly accelerate collection of new data and the re-checking of old material for the encyclopedia.

Withered Hand May Appear on Packages

➤ A PICTURE of a withered hand on a package label may soon tell transportation and chemical industry workers throughout the world that the container holds dangerously corrosive chemicals, just as the familiar skull and cross bones warns of poisonous contents.

Representatives of 18 Free World governments favored adoption of uniform pictorial symbols to mark containers of five classes of dangerous substances common to international shipping.

The reports were presented at a Geneva meeting of the Chemical Industries Committee of the International Labor Organization, a United Nations agency.

As a method of overcoming language barriers, most of the governments also favored a set of picture symbols to represent other common hazards. Those suggested at the meeting of the committee, in addition to the skull and cross bones and the withered hand, are: explosion, a round ball exploding; ignition, a flame; radiation, skull and cross bones over a capital R in a square box.

Stellar Temperatures Reproduced

► STAR-LIKE temperatures in excess of a million degrees, which could in the future lead to successful control of thermonuclear reactions for peaceful power, have been reached in the Naval Research Laboratory, Washington.

Dr. A. C. Kolb reported his experiments in momentarily reproducing stellar atmospheres to the recent Optical Society of America meeting.

Although his work is aimed at developing reliable methods for measuring the temperatures and pressures of gases at very high temperatures, the equipment used has all the necessary "ingredients" for controlling fusion reactions, Dr. Kolb told Science Service.

The possibility of producing power from the virtually unlimited supply of heavy hydrogen in the world's oceans has stimulated high-temperature research in many countries.

The method used to produce the high temperatures at NRL is to accelerate ionized gases to velocities approaching 500,000 miles an hour in a shock tube by electromagnetic forces. Temperatures can be inferred from the measured speed of the shock wave, Dr. Kolb said.

The problem is that complicated processes can affect the accuracy of temperatures inferred in this way. By analyzing the light produced by shock waves, more accurate temperature measurements are in prospect.

At the Naval Research Laboratory the hot gases are kept away from the cold walls of the shock tube by a method that reverses the so-called pinch effect. At NRL, the shock tube containing the gas is surrounded with coils that carry high currents, and these currents produce a magnetic field that pushes the gas into the tube's center.

In a pinch tube, currents are passed along a tube and the resultant magnetic fields encircle the pinched gas.

The currents for the coils are produced by discharge of a large condenser bank that is rated at 20,000 volts. When discharged into a short circuit, 15,000,000 amperes are possible, a peak power of nearly 100 billion watts.

New Tool For Radioactivity Analysis

► COLUMBIA RIVER water used for cooling large production reactors at the Hanford atomic plant must be checked carefully for radioactive content.

An instrument designed to detect trace quantities of radioactive materials that may be present in the river has been perfected by R. W. Perkins, General Electric chemist. It can be used to identify sodium-24, manganese-56, copper-64, arsenic-76, chromium-51, neptunium-239, zinc-65, scandium-46, barium-140, cobalt-60 and manganese-54.

Replacing traditional chemical procedures, a sample of river water is placed in a probe which consists of an activated sodium iodide crystal and a multiplier phototube sealed in an aluminum can. The solids dissolved in the water are then concentrated by evaporating the water.

New Nuclear Discoveries Predicted

➤ ENERGY GREATER than that now being obtained from the fission of atoms in reactors or that might be extracted from the peaceful fusion of hydrogen nuclei lies hidden in the particles making up the nucleus.

Although the energy is there, no scientist can yet tell whether it will ever be used, Dr. M. Stanley Livingston, physics professor at Massachusetts Institute of Technology, told the recent MIT regional conference in Washington.

The main reason for building new and larger accelerators, or atom smashers, is to learn more about these particles. He said billions of volts of energy were needed to penetrate and disrupt the nucleus, revealing for very brief lifetimes the particles of which it is composed.

Experiments to date now allow scientists to see "the early beginnings of a theory of matter," Dr. Livingston reported, but many more years of research will be needed before a valid theory can be established.

Although man now knows how to trigger the release of energy by fissioning atoms, as prehistoric man learned to burn fuel for heat, no one knows the origin of or detailed properties of the nuclear forces involved.

"Our basic goal is to learn the nature of matter itself," Dr. Livingston said. "If in the future some useful application to human needs comes from these beginnings, it will only be repeating our past experience and will again justify our faith in the ultimate utility of basic research and the search for knowledge."

He pointed out that scientists are now on the "threshold of exciting new discoveries about the fundamental particles of which the world is composed."

Dr. Livingston noted that particle physics goes as far beyond nuclear physics as that went beyond atomic physics and chemistry. The challenge of learning the nature of matter is "dramatic to an extreme," he said, with advanced students flocking into this field of science.

Dr. Livingston is director of the Cambridge Electron Accelerator, a six billion electron volt machine being built as a joint project of scientists from MIT and Harvard University and supported by the Atomic Energy Commission.

√ Answers to CHEMISTRY QUIZ on page 25. √

1, 4; 2, 1; 3, 3; 4, 1; 5, 1.

Molecular Structure Determines Properties

The Elasticity of Rubber

by LEONARD MULLINS

(Reprinted from THE NEW SCIENTIST, October 31, 1957, with permission)

THE MOST striking property of rubber is its elasticity. It can be stretched to several times its original length, and it recovers rapidly and completely on release — in contrast to the behavior of metals, which can be stretched only by a small fraction of one per cent before they yield plastically and break. In further contrast to metals, rubbers are extremely soft. A typical vulcanized rubber deforms under a force about a 100,000 times smaller than that needed to produce the same deformation in a metal.

For all its remarkable elastic properties, it is only in the last twenty-five years that physicists have thought rubber a worthwhile material to study.

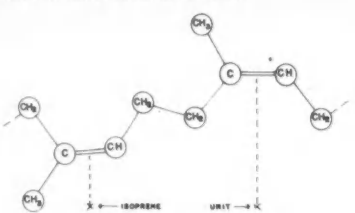
First hints of the explanation of its elastic properties were contained in the early works of Lord Kelvin (1824-1907) and James Prescott Joule (1818-1889). Much of the early work on rubber attempted to relate its chemical composition to those properties. But it is now clear that many other substances — for example, animal muscle, gelatin, one form of sulphur and a host of materials known as polymers, which contain a succession of similar repeating units arranged in long molecular chains — are capable of showing 'rubber-like elasticity.

The reason for the marked difference in the elastic behavior of rubbers and metals is that there is a fundamental difference in the arrangement of their atoms. In metals the atoms are arranged in a rigid geometric pattern, with each atom at a fixed distance from its neighbors. The atoms retain these positions firmly, and large forces are needed to squeeze the atoms closer together (and so compress the metal) or to pull them apart (and thus extend it). When the force is removed, the atoms normally spring back to their original positions.

Rubbers, on the other hand, are made up of flexible molecules, consisting of a number of identical "building-blocks" — sometimes as many as 10,000 — joined together end to end. In natural rubber each building-block is a molecule of the simple compound of carbon and hydrogen called isoprene. Isoprene is found in its simple unjoined-up form as an oil refinery by-product. Recently a synthetic "natural" rubber has been made by linking together isoprene molecules by chemical means. Other synthetic rubbers are made up of similar long flexible molecules but with building blocks of different simple chemical compounds.

Using the symbol C for carbon atoms and H for hydrogen atoms,

part of the long natural rubber molecule would look like this:



The carbon atoms form the spine of the molecule. Such a molecule is inherently flexible. The majority of the links joining carbon atoms together are single, allowing the atoms to rotate relative to their neighbors, just as if the link was a single wire. Only the "double bonds," marked X, lock their pairs of carbon atoms firmly together and do not allow them to rotate — as though the link were two spaced wires.

These flexible long chain molecules are in constant motion as a result of the thermal energy of the atoms. The motion of the rubber molecules is rather similar to the random buffetings and thermal motion of molecules in a liquid, with the difference that the moving elements, instead of being entirely independent, are linked together to form long chains. Thermal agitation and collisions between neighboring molecules cause them to kink-up and unkink in a disorderly way. As molecular movements are always in progress, the shape of any molecule does not remain fixed, and it may take up any of an almost infinitely large number of possible shapes; but it is easy to see that the majority of the configurations taken up by a molecule will be more or less highly kinked.

One further factor must be mentioned before our picture of the molecular structure is complete — a factor which distinguishes the behavior of rubber from that of a liquid. We envisage a piece of raw rubber as a mass of closely intertwined long chain molecules. Under the action of a force the molecules deform, and some will succeed in disentangling themselves and flowing past neighboring molecules. Permanent plastic deformation then results.

To convert the rubber into an elastic material which returns to its original shape and size after deformation, it is necessary to introduce sufficient chemical links between neighboring molecules — known as cross-links — to convert the whole structure into a three-dimensional network. This is the essential function of vulcanization; sufficient cross-links are introduced during vulcanization to lock all of the molecules into a network, but at the same time, leave reasonably long lengths of the chains capable of moving and free from restriction.

The tendency for rubber molecules to take up randomly kinked shapes as a result of thermal motion is the fundamental concept of the now generally accepted theory of rubber-like elasticity. Unlike metals, the deformation of rubber only involves some sort of molecular straightening or rearrangement in which little work is done against interatomic or intermolecular forces. For this reason, relatively little force is needed to stretch a piece of rubber compared with a metal.

From this picture the kinetic theory (*Kinetikos:* motion) of rubber-like elasticity has been developed, and it now provides a quantitative basis to describe elastic behavior of rubbers.

The development is essentially a mathematical one, but its significance can be readily grasped without going into detail.

In many respects the development of this kinetic theory of rubber-like behavior is analogous to that of the kinetic theory of gases. The latter theory assumes that the molecules of gas behave like tiny, perfectly elastic billiard balls which are continually colliding with one another. Using this simple concept it is possible to work out the behavior of a gas — how its volume changes with pressure and its pressure with temperature. The laws developed in this way describe accurately the behavior of gases over a wide range of conditions.

A similar simplification is used in the kinetic theory of rubber. The actual detailed molecular structure is ignored. Instead, the rubber is regarded as made up of chains; each chain contains a large number of links joined together at random, and the chains are joined together to form a network by the appropriate number of cross-links. The chains (like the perfectly elastic billiard balls with which we replace the molecules of the gas) are in continual motion. At one moment the chain will be very kinked and twisted round on itself; a little later it may be extended in a straight line to its full length.

Starting from these assumptions it is possible to work out the likelihood of a chain being in any particular configuration. It turns out that, at any moment, more chains will be highly kinked than in any other condition. When the rubber is deformed the chains are extended from the highly kinked state to a less kinked condition. This change from the most probable state to a less probable one requires the expenditure of some energy. In other words, a force has to be applied to the rubber to make it extend. The magnitude of this force can be determined by calculating the relative probability of the chain configuration in the deformed and undeformed states. To put this another way, we see that the elastic properties of rubber are related to the thermal motion of the chains, just as the pressure of a gas is related to the thermal motion of the molecular billiard balls.

For gases, the kinetic theory predicts that the pressure will be proportional to the absolute temperature, and experiment bears this out. In the case of rubber, the kinetic theory predicts that the tension on a deformed piece of rubber is proportional to its absolute temperature, and surprisingly good agreement is found between this prediction and the properties of real materials.

The reason why rubber can be stretched so far without breaking is also now apparent. When one of the chains is highly kinked its ends are close together; the average distance apart of the ends can be calculated from the kinetic theory. For a typical soft vulcanized rubber, the ends of the kinked chains are on average about one-fifteenth the distance between the ends of the fully extended chain, and we should expect to be able to extend a piece of such rubber in roughly this ratio, when most of the kinked chains will be straightened out.

It is encouraging to find from experiments that this kind of rubber will extend to approximately ten times its original length before it breaks.

Of course, one cannot expect such very simple ideas to explain all the properties of rubber. Significant departures from the predictions of the kinetic theory do occur, for example, when forces between the molecular chains become appreciable and restrict motion. If this happens, the molecules cannot rearrange themselves rapidly, and the rubber is slow to recover its shape after it has been deformed. If the forces between molecules are very large, the molecules will not rotate at all — they will merely vibrate, and the material will be rigid and not rubber-like. If such a material can be heated so that the vibration of the molecules is increased sufficiently to overcome the intermolecular forces, then the material will show the flexibility and behavior characteristic of natural rubber at normal temperatures.

A similar pattern of behavior is shown by natural rubber when it is cooled to low temperatures. As the temperature is decreased the molecular chains become less energetic: the rubber grows sluggish and leathery until at about −70°C. it is rigid and brittle.

This descriptive account of the molecular origin of rubber-like elasticity cannot do justice to the increased understanding of elastic behavior which has been provided by the new framework of thought and ideas. The kinetic theory accounts so well for an increasing number of observations that its position today is unchallenged, and there is abundant evidence to encourage the belief that in the future engineers will be able to design articles in rubber with the same confidence that they now have in designing with metals.

On the Back Cover

➤ NEUTRONS SPEED *from a split uranium atom at approximately 6,000 miles a second, and must be slowed down to about one mile a second if fission is to be properly sustained. High purity graphite has proved to be one of the best materials with no practical melting point, so it is unaffected by extremely high temperatures. It can be easily machined into intricate shapes, and here hexagonal columns of graphite, sealed in zirconium cans, are being installed in the reactor core tank of the first non-military nuclear reactor to produce commercially distributed electricity. Designed and built by Atomics International, the sodium-cooled, graphite-moderated reactor is part of the AEC's program to develop basic technology for economical nuclear power plants. Graphite columns also serve in the reactor as a reflector, scattering the neutrons and directing some back into the core, permitting increased power output from a given mass of fissionable fuel. Manufactured by National Carbon Company, Division of Union Carbide Corporation, the accurately machined graphite was enclosed in zirconium to prevent the liquid sodium, used as a cooling medium, from penetrating its pores and being absorbed.*

Reds Reveal Future Science Plans

➤ ROCKET-POWERED airliners flying at 10,000 miles per hour; transparent and transportable houses; a disease-free environment; self-controlling and self-checking factories and excursions to the moon.

These are some of the promises of science in the foreseeable future, according to Soviet scientists.

Guided by the new slogan, "The Future Is Being Made Today," Russian scientists have taken a peek into the immediate future in the current issue of U.S.S.R., the English language Russian magazine published and sold in the United States.

This is what they predict:

1. Tomorrow's Cities — Russian houses of tomorrow, according to Academician Pyotr Rebinder, will be thin-walled, graceful structures that are easy to build, easy to transport, and simple and inexpensive to heat and to cool. They will be transparent but "strong and lasting." They will be made of a new building material that will be easy to mold, process, stamp and will assume any shape desired. Unusual cities will also be built.

2. Tomorrow's Health — Medicine, predicts Prof. Irina Lagunova, "will have been altered from a science of healing to a science of prevention, one which will have destroyed all sources of disease, and left for the physician only the problem of keeping his patients healthy." The use of radiant energy and high-frequency energy have already been used to destroy harmful bacteria, Prof. Lagunova points out. Radioisotopes promise complete control of every major gland of the body. "Experimental medicine in the Soviet Union has succeeded in reviving the human organism after clinical death has set in. It has been able to restore to elderly people lost hair color, memory, capacity to work, hope for longevity."

3. Tomorrow's Rocket Plane—The "airliner of tomorrow" will shoot like a rocket into outer space, taking off vertically, but landing like conventional airplanes. It will fly at heights of 600 miles and at speeds of 10,000 miles per hour. According to Vasili Alexandrov of Technical Sciences, Soviet science is rapidly developing techniques that make the creation "of such planes possible."

4. Tomorrow's Machine — The complete automation of the future, claims Prof. Grigori Shaumyan, "is not only a blueprint, its development is already in process and has been for some time." Latest advances in the Soviet Union, he reports, have been created that can be set to reproduce the best human control of a machine tool and function independently of an operator. One such automated device machines crankshaft pins on a lathe. Complete automation controlled electronically, Prof. Shaumyan predicts, will handle the most complicated technological processes without the need for human interference.

5. Tomorrow's Oceans — Subma-

rine farming will help feed hungry people. Swarming masses of plankton will be scooped out of the sea to be converted into fodder for animals. The oceans' storehouse of seaweed will be tapped for food and industrial uses. "In the future not too far distant," says Lev Zenkevich, a corresponding member of the U.S.S.R. Academy of Sciences, "we can envisage a vast and well-ordered marine economy, with minerals extracted from the ocean floor, energy from its waters, food from its rich stores of plant and animal life."

6. Tomorrow's Earth Depths — "A plentiful mineral future is foreshadowed," according to Academician Dmitri Shcherbakov, by mining the depths of the earth. "Preliminary, but successful" experimentation in Russia has already yielded basalt which can substitute for rare earths or be used as a building material. Soviet scientists have also extracted nephelite and worked out a method for wringing aluminum, potash and soda from it. "The time will come," Academician Shcherbakov says, "when the subterranean machine, working on atomic fuel independent of the surface, will penetrate deep into the bowels of the earth, breaking up and melting rock as it burrows in search of ore deposits."

7. Tomorrow's Star Flights — The plane that we know today will be replaced by "the cosmic ship which will fly at speeds varying anywhere from 40,000 to 60,000 miles per hour." A flight to Mars in the "nuclear or radiant" powered space ship will take a year. "It may very well be that within a matter of decades," Victor Kaznevsky, a design engineer, states, "our neighboring planets will no longer be offering a challenge. The distant stars will be our goal."

Radiation Improves Metals

➤ MANY PROPERTIES of metals can be improved by "damaging" them with nuclear reactor radiation, two former Atomic Energy Commission scientists told the Nuclear Engineering and Science Conference in Chicago.

Seven non-fissionable metals, including stainless steel, nickel, titanium, copper and iron, were treated under various conditions with irradiation from three types of nuclear reactors by Dr. C. A. Bruch and W. E. McHugh at the Knolls Atomic Power Laboratory, Schenectady, N. Y.

The strength, hardness and electrical resistance of all the metals increased, the scientists reported. In each case, they said, there was a decrease in ductility, or the ease with which the metal could be drawn into a thin wire.

On the basis of their studies, the scientists have developed a picture of the radiation damage process, as changes caused by irradiation are called, which they hope will be applicable to other metals and to other conditions of radiation.

If their theory of radiation damage proves to be correct, they said, it may be possible to speed up future studies of radiation damage.

The changes in properties or radiation damage in non-fissionable metals are due primarily to the scattering of neutrons by the metal atoms, they said.

High Altitude Craft Would Make Fuel

▶ A SMALL, unmanned airplane that carries no fuel, but will be capable of manufacturing its own fuel from trace quantities of material present at the high altitudes was described to the 133rd National Meeting of the American Chemical Society in San Francisco.

The revolutionary idea is also expected to lead to development of a much larger craft that will continuously circle the earth, gathering and storing nature's own fuel components. These could be used to feed other space craft as they prepare for their flights into farther space after being propelled to the fuelling craft's altitude by conventional propellants.

Operate on Atomic Oxygen

The feasibility of operating such aircraft on small amounts of atomic oxygen present at approximately 60 miles above the earth's surface was described by S. T. Demetriades and Dr. C. B. Kretschmer, Astronautics Laboratory, Aerojet-General Corp., Azusa, Calif., and M. Farber, Hughes Aircraft Co., Culver City, Calif.

Ordinary oxygen exists in a molecular form, with two oxygen atoms combined to form one gaseous oxygen molecule. Probings of the earth's upper atmosphere with high altitude sounding rockets have revealed the presence there of uncombined oxygen atoms in small quantity.

Considerable energy is released when two oxygen atoms combine. It is this energy that would provide power for the proposed space craft.

The California scientists' calculations indicate enough thrust could be developed from the naturally-occurring fuel elements to overcome the slight drag a ship would encounter at the 60-mile altitude.

The scientists envision a practical application for a ship that could be built in the immediate future. Since the craft would have to be extremely light and have a large surface area, it could be made of thin metal foil and act as a wide-range television reflector or micro-wave relay station.

A first small, unmanned ship also would provide scientific data necessary for building the proposed flying rocket propellant factory.

The larger ship not only would operate on the power of recombined oxygen from its environment, but also would collect and store atomic oxygen.

Crystal Growing

▶ AN IMPROVED technique for growing single crystals of binary semiconductors which decompose on melting was described to the American Chemical Society San Francisco meeting by Dr. J. M. Whelan of Bell Telephone Laboratories. The basic experimental work was performed on gallium arsenide, but the method should be applicable to a variety of compounds which are thermally unstable at their melting points.

➤ Dr. J. M. Whelan *of Bell Telephone Laboratories is shown examining the molten zone of a gallium arsenide rod, during a crystal growing experiment.*

According to Dr. Whelan, the floating zone method appears to be superior to other methods for growing GaAs single crystals. Composition of the liquid phase at the melting point is strongly dependent on the partial pressure of arsenic. This is most easily controlled by using a sealed system containing excess arsenic and regulating its minimum temperature. The rate of growth is easily controlled and spurious nucleation is greatly reduced by the thermal symmetry of the freezing interface.

Other advantages of the method are the reproducibility, regularity of impurity distributions, and the minimization of apparatus contamination. The relatively large surface-to-volume ratio favors the approach to equilibrium between the liquid and vapor phases. In addition, the small liquid volume minimizes temperature variations in the melt, and the consequent concentration gradients of the principal components.

Surface Tension Utilized

The technique should be most useful with binary compounds in which only one of the component elements has a considerable vapor pressure at its melting point. The compound must have a high enough electrical conductivity to allow heating by radio frequency induction. The surface tension and density of the molten material must also be such as to support a molten zone during the process.

In the basic floating zone refining technique, a rod is supported vertically. A heat source, for example an induction coil operated at radio frequencies, is moved relative to the rod, melting a liquid zone as it moves. Surface tension supports the liquid zone. Usually by this method, a single crystal can be grown and purification achieved in the zone refining.

Ca Versus Sr^{90} in Soil

➤ Man can protect himself from the dangers of radioactive strontium-90 fallout in his food by chemically treating garden soil and by switching his tastes in vegetables.

Treat garden soil with lime and learn to eat more plants that do not readily pick up strontium from the soil. These are the life-saving proposals reported by Dr. Eric B. Fowler, Los Alamos, N. Mex., Scientific Laboratory of the University of California.

Bone cancer-causing strontium-90

from nuclear test fallout may pose a serious threat to man by entering the foods he eats, Dr. Fowler said.

Based on the Los Alamos research, lettuce and alfalfa could be considered "safe" plants, and various grasses would have to be called unsafe for humans and animals with respect to their ability to take up strontium-90.

Group II Analogs

Strontium is chemically very similar to calcium, which is normally absorbed from the soil by plants. Plants that pick up needed calcium from the soil also will pick up dangerous strontium-90. To reduce the strontium-90 uptake, Dr. Fowler said, it is necessary to make calcium much more available to the plant.

Experiments performed in New Mexico as part of "Project Green Thumb" show that large quantities of calcium, in the form of lime, added to plant-growing soil considerably reduced the strontium-90 uptake of lettuce, alfalfa and grass, Dr. Fowler reported.

He suggested the lime be added to soil in the form of limestone, which is nearly half calcium.

Plants such as lettuce and alfalfa "seemed to prefer calcium to strontium and during their growth acquired less strontium from the soil than would be expected." Other plants, such as grass, preferred strontium and appeared to concentrate strontium as they grew.

The Los Alamos chemists pointed out that other scientists have reported that strontium-90 from radioactive fallout concentrates in the upper two to four inches of soil and that plants with deep roots absorb only a small amount of radioactivity.

They suggested that "food for humans and cattle obtained from deep-feeding plants may be important sources of nutrient low in strontium."

Co-authors of the report, all of the Los Alamos laboratory, were Richard G. Thomas, George L. Johnson, Mitchell A. Melnick, Elgin H. Rex, Felix A. Vigil and C. W. Christenson.

Vital Hormone Synthesized

➤ The vital hormone that controls the salt balance of the body has been prepared directly from coal tar products. The accomplishment could make aldosterone more readily available for the treatment of human disease, such as the dreaded Addison's disease.

The chemists who reported their synthesis said it still is too early to do more than speculate on what significance their work will hold for physicians.

They pointed out, however, that aldosterone can be extracted from adrenal glands only in very small amounts, and the only practical way to obtain it in quantities large enough for wide medical study is through synthesis.

Before the synthetic aldosterone can be made available for routine salt level control in humans, it must first be produced in quantities large enough for testing chemically, and in animal and hospital experiments, Dr. William S. Johnson of the University of Wisconsin said.

Dr. Johnson headed a research team consisting of Drs. Joseph C. Collins, Raphael Pappo and Mordecai B. Rubin, also of the University.

Partly for the total synthesis of the

important body chemical, as well as for previous work, Dr. Johnson received the American Chemical Society $1,000 award for creative work in synthetic organic chemistry. Earlier, he synthesized the female hormone estrone and performed the first total synthesis of the male sex hormone testosterone.

The salt-retaining aldosterone first was totally synthesized in 1955 by Dr. Arthur Wettstein and a team of Ciba Company scientists in Switzerland, Dr. Johnson said.

The synthesis described today was the first to be based on a very readily available coal tar chemical, 1,6-dihydroxynaphthalene. That chemical was chosen as a starting point, Dr. Johnson said, because it is very similar in structure to some parts of the aldosterone molecule.

Following the addition of two more compounds plus treatment in some 30 separate chemical reactions, a few crystals of the hormone were obtained.

The yield was only "about equal to the amount of salt from one shake of a saltcellar," Dr. Johnson said, but it was sufficient for positive identification.

Anti-Leukemia Drug

➤ A DRUG that greatly increases the life span of mice with advanced leukemia has been discovered by National Cancer Institute scientists.

The new synthetic compound has produced a 75% increase in survival time beyond that achieved with methotrexate, a drug widely used to treat human leukemia, when tested against mouse leukemia.

The new drug has not yet been tested against leukemia in humans. It was found during a program of routinely testing the anti-leukemia action of a large number of chemicals by scientists at the National Cancer Institute, National Institutes of Health, Bethesda, Md.

The drug was identified as 3',5'-dichloroamethopterin, a derivative of the drug now in use to fight human leukemia, by Dr. Abraham Goldin, head of the biochemical section of the laboratory of chemical pharmacology.

Mice that normally would live only two or three days after leukemia has spread throughout their bodies can live for more than 50 days when treated with the new drug, Dr. Goldin said.

Survival time increases with increasing dosage until a level is reached at which the drug is too toxic, the scientists found.

Co-authors of the report were John M. Venditti, Stewart R. Humphreys, Dr. Louis Shuster and Dr. Robert A. Darrow, laboratory of chemical pharmacology, and Nathan Mantel of the biometry branch.

The new drug was synthesized by chemists of the American Cyanamid Company, Pearl River, N. Y. Drs. Robert B. Angier and William V. Curran of American Cyanamid reported on the chemistry of the drug at the ACS meeting.

Dr. Goldin said results of the NIH experiments emphasize its need to study systematically compounds related to chemicals with known medical value. He indicated that other compounds related to methotrexate are undergoing similar study.

Two Types of Diabetes

▶ HUMAN BEINGS suffer two distinct types of diabetes.

Diabetes can no longer be considered simply as one disease to be treated with insulin, Dr. Henry Dolger, chief of the diabetes clinic of Mt. Sinai Hospital, New York, reported.

The new drug Orinase, taken by mouth instead of by injection, has proved to be effective in more than 50% of adult diabetics, and "has thereby created the first separation of diabetes into two categories," Dr. Dolger said.

Many medical researchers have felt that the condition of diabetes mellitus, commonly called simply "diabetes," actually represents a number of different kinds of diabetes. However, until now they have had no proof.

Orinase Provides Proof

Studies using Orinase show, Dr. Dolger said, that persons afflicted with diabetes fall into two groups: 1. those who have no insulin available to begin with, and 2. those who have insulin available but suffer some interference with its proper liberation and use.

Insulin is a hormone secreted by the healthy pancreas. It helps the body convert food into energy. A person suffering diabetes is not able to utilize properly all the available sugar and starch to produce energy. Excess body sugars are passed into the blood and urine.

Injections of insulin help patients suffering both categories of diabetes. Orinase has been helpful, Dr. Dolger said, in a majority of patients who have insulin available in their bodies but have not been able to utilize it properly.

"This is a most important implication for the future elucidation of the cause of diabetes, and this definition into two groups will afford a better research material and a clearer understanding of the disease," Dr. Dolger declared.

Plant "Heart Attacks"

▶ PLANTS such as bananas, tomatoes, and peas can suffer "strokes" and "heart attacks" caused by clots in their veins just as humans suffer attacks due to clots in their blood vessels, the assembled chemists learned.

Two University of Wisconsin scientists identified the causes of several widespread and economically important plant wilts and reported a method of developing plants that are resistant to the diseases.

Death-dealing wilts of many vegetables as well as cotton plants, oak and elm trees were blamed on a soil fungus by Drs. Mark A. Strahmann, department of biochemistry, and J. C. Walker, department of plant pathology.

Fusarium fungus, a simple plant having no root, stem or leaf system and similar to molds, toadstools, bacteria and yeast, may penetrate a plant's vascular system, Dr. Stahmann said.

Similar to Blood Clot

Once inside the plant's veins, or "blood vessels," the fungi produce a

substance, an enzyme, that attacks some of the pectin in the vessel walls, the chemist reported.

Pectin fragments then break off into the vascular stream where they form gelatinous masses of clots that plug the vessels. This action is similar to blood clots clogging human blood vessels to cause strokes or heart attacks.

Fortunately, Dr. Stahmann said, some varieties of the plants investigated are not susceptible to wilt diseases and it is possible to develop resistant plant strains.

Using their new understanding of wilt disease causes, the scientists then began the difficult task of finding out exactly what enables certain plant strains to resist wilt.

Although they have not completely identified the resistance mechanism, they reported that the resistant plants seem to produce a substance toxic to the invading fungi. Also, they reported, the disease-resistant plants apparently fail to produce normal amounts of another enzyme that is essential to the formation of the fatal pectin plugs.

Besides bringing to plant scientists a better understanding of wilt disease causes, Drs. Stahmann and Walker expect their research to lead eventually to control of those diseases.

Hay Fever Cause Isolated

➤ THE SINGLE chemical agent that causes hay fever has been extracted from ragweed pollen and identified.

Identification and study of the agent responsible for hay fever is expected to make possible more effective relief for the millions of persons who suffer the summertime allergy.

Trifidin A, as the agent is called, was separated from extracts of giant ragweed pollens by Drs. A. K. Bhattacharya and A. R. Goldfarb of the Chicago Medical School.

The substance by itself has proved almost as effective in producing hay fever as the total pollen extract, Dr. Bhattacharya said. It may exist uncombined in the pollen, he reported, or it may be hidden in a complex mixture of other pollen components.

Ragweed pollens are a major cause of hay fever and asthma, which are the most common constitutional allergy symptoms found in the United States. Dr. Bhattacharya pointed out that previous studies of these widespread conditions indicated the presence of several substances which singly, or in combination, can produce the allergies.

Earlier work also showed that the allergy-producing agents could be separated into two categories: those that react with skin and those that do not. This, Dr. Bhattacharya said, confirmed the belief that the agent producing allergy symptoms is a single chemical structure occurring either in the free state or combined with carriers.

Separation of Trifidin A was accomplished by repeated treatments of pollen extract with solvents, followed by ion exchange and chromatographic refining, the chemists reported.

New Catalyst System

➤ A NEW CATALYST system for ethylene polymerization was revealed at the meeting. Comprehensive details of the catalyst mechanism and characterization of the polymer type were disclosed in two technical papers presented by J. J. Smith and W. L. Carrick of the Research Department of Bakelite Company, Division of Union Carbide Corporation, Bound Brook, N. J.

In a statement issued with the papers, Dr. F. H. Roberts, Vice-President - Research of Bakelite Company confirmed the fact that the investigation creates a new body of information on how to produce high-density polyethylene.

He discounted any immediate commercialization by emphasizing that the development is still within the sphere of research. "It must be considered," he cautioned, "no more than an encouraging milestone in the Company's continuing study of catalytic olefin polymerization.

"The primary importance of these extensive studies is the better understanding they provide of how organometallic catalysts function. It is through knowledge of this type that we believe improved polyolefins will eventually be obtained."

Metal-organics

According to the original research findings, a system of tetraphenyl tin and aluminum bromide formed an efficient catalyst for low pressure ethylene polymerization. The unique aspect of the laboratory discovery lies in the fact that vanadium compounds are an essential ingredient of the catalyst. Minute traces of vanadium bromide are normally present in commercial aluminum bromide, but usually considered an impurity.

Also significant in the report is the statement that the catalyst system is completely soluble in hydrocarbon diluents.

The recently-developed catalyst, the Bakelite scientists reported, had been used to prepare laboratory samples of ethylene polymers. Tests conducted on these samples indicated that material produced this way possesses a linear molecular structure, high molecular

➤ RESEARCH CHEMISTS, *W. L. Carrick, left, and J. J. Smith, assemble apparatus for studies on low-pressure ethylene polymerization. From this grillwork of laboratory equipment came a new method of creating high density polyethylene from ethylene gas. It is based on vanadium compounds that provide the "spark" for the chemical reaction.*

weight, and narrow molecular weight distribution.

Review Many Catalysts

The report on the catalyst mechanism is acknowledged to be a comprehensive study not only of the vanadium halide system, but also of organometallic catalysts currently used in commercial polymerization processes. The research data emphasize the novelty of the vanadium function and the extremely small concentrations required for comparatively high product yield.

The formation of soluble complexes between the components of the catalyst system led the researchers to the proposal of a logical reaction mechanism for organometallic catalytic systems.

This mechanism was applied in research studies to other organometallic systems by means of organovanadium compounds. The studies, according to the report, provide evidence that clarifies the basic mechanism of the catalytic activity of some of the more prominent organometallic catalysts.

Vegetable Oils Replace Tin

➤ HARD PLASTIC films made from vegetable oils could replace tin coatings on food cans, and may be used as protective coatings on building materials and machinery.

The coatings, produced from linseed and soybean oils, stick unusually well to the black iron and aluminum from which many cans are made.

The plasticized vegetable oil coatings are flexible and resistant to abrasion and stain by harsh chemicals, Dr. H. M. Teeter, U. S. Department of Agriculture Northern Research Laboratory, Peoria, Ill., reported.

Unusually Strong

The adherence of the new finishes to metal cans is so strong, Dr. Teeter said, that "discs stamped from metal covered with the new coatings were formed into lids and then crimped into place on the can body without any breaks in the film."

Dr. Teeter reported that he and his co-workers, Drs. L. E. Gast and J. C. Cowan, treated the vegetable oils with sodium to convert them into fatty alcohols that in turn, were treated with acetylene to produce vinyl ethers.

Molecules of vinyl ethers then were polymerized, linked together, to produce the new coatings related to familiar vinyl plastics.

Prof. Natta on Polymers

➤ A NEW poly-butadiene now under laboratory test which can be extruded and stretched to produce crystalline fibers which behave much like muscle proteins; a new synthetic rubber with properties similar to natural rubber; and a new group of low cost polymers which can be "tailored" to given end product needs are among the new chemical wonders revealed at the meeting.

According to Professor Giulio Natta, director of the Polytechnic Institute of Milan, Italy, in a talk before the ACS Division of Polymer Chemistry, his research group in its investigations on the configurations that macromolecule chains take in crystals

➤ Prof. Natta

has prepared a number of unusual synthetic high polymers.

One, of great scientific interest, a "1-4 trans polybutadiene" behaves very much like muscle proteins in that a reduction of length of the oriented synthetic fiber results in the transformation of the fiber from one crystalline phase to another. Another polymer, a "1-4 cis-polybutadiene" has many of the properties of natural rubber with excellent tensile strength in the absence of fillers. It is Professor Natta's belief that *this* particular polymer promises to be of "enormous practical importance."

Propylene Plastics

Prof. Natta also revealed the success of his group in its efforts to regulate the molecular weight and steric purity of certain other high polymers. It is possible, he said, to synthesize directly polymers of polypropylene (a giant molecule based on low-cost propylene gas) with pre-determined molecular weight. This "molecular architecture" means that the chemist and engineer are now able to "tailor" molecules for given end product needs.

The first of these "tailored" materials to be based on Prof. Natta's discoveries and inventions was recently introduced commercially into this country by Italy's Montecatini Company as "MOPLEN" isotactic polypropylene, a new and revolutionary family of plastics with unusual heat resistance, excellent chemical resistance, mechanical and electrical properties. (See CHEMISTRY, Dec. 1957, p. 9.) Housewares, mechanical parts, automobile items molded of "MOPLEN" are currently being marketed in Italy.

Isotactic polypropylene can also be structured to yield unusual synthetic fibers, and its copolymers may yield elastomers which show superior properties. Natta reported that his group had obtained certain amorphous copolymers which exhibit resistance to aging and a tensile strength in the vulcanized state that are higher than those shown by natural rubber and with a resilience generally better than that exhibited by other GRS synthetic rubbers.

A new systemic insecticide under development, Bayer 21/199, has been found highly effective in combatting grub infestations in cattle.

Sales of reinforced plastics reached the 168,000,000-pound level in 1957, a 20% increase over 1956.

Free Radicals and Cigarette Smoke

➤ CIGARETTE SMOKE may be a more important factor in lung cancer than previous tests have indicated and a new method of testing the possible cancer-producing effects of smoke is needed, three scientists have reported.

Cigarette smoke products, such as tars, usually have been tested cold and after an appreciable lapse of time from when the cigarette was mechanically "smoked" by a smoke collecting machine.

The new report, published in the British scientific journal *Nature* (April 5), points out that those smoke products most likely to be possible cancer-producing agents exist only while hot and only for a few seconds. However, during their very short lifetimes the products are extremely active and possibly capable of providing the long-sought chemical step between harmless substances and cancer-producing agents.

The research was performed by Drs. M. J. Lyons, cancer research department, Royal Beatson Memorial Hospital, Glasgow, and J. F. Gibson and D. J. E. Ingram, University of Southampton.

They stated that their work was based on current theories that chemical radicals existing in the very active, short-lived uncombined state may be intermediaries of cancer formation.

When atoms habitually organize themselves into identifiable groups that act as single units, they are called radicals. For example, the arrangement of one carbon and three hydrogen atoms ($-CH_3$) is known as the methyl radical and can combine with many other atoms or groups of atoms to form a wide range of methyl compounds, such as CH_3OH_1 methanol (methyl alcohol).

Normally, a radical does not exist in a free state, but is combined in a compound. However, heat, light, electricity or other chemicals can cause compounds to split momentarily, freeing the radical as a short-lived and highly active chemical unit which either recombines with the atoms from which it was split, or combines with other available atoms to form new compounds.

The British researchers measured significant amounts of free radicals present in hot smoke as it came from cigarettes. In the cooled and condensed tars they found very few free radicals.

The scientists concluded that the possible cancer-causing free radicals had recombined to a relatively inactive state by the time smoke products were used in the usual cancer studies and cannot give a true test of cigarette smoke's potential cancer-producing ability.

Colored rubber can now be made into tires that are comparable in every respect to those made of the best black compounds, due to new silica reinforcing pigments.

It is foreseen that solar batteries will power automobiles within the next couple of years.

Nb and V Found in Ocean Waters

▶ THE OCEANS of the world may some day provide our major supply of the currently strategic metals, niobium and vanadium, just as they now provide the bulk of our magnesium.

Scientists at Plymouth, England, have found appreciable quantities of both metals in the flesh and blood of ascidians, a family of sea animals represented by the familiar skate.

Evidence indicates that niobium, at least, is absorbed in some way by the animals from sea water, Drs. D. B. Carlisle and L. G. Hummerstone, Marine Biological Association Laboratory, Plymouth, reported in the British scientific journal *Nature* (April 5).

Niobium, sometimes called columbium, and vanadium recently have achieved importance in hardening high-quality steel and in making aircraft steels corrosion resistant and more useful at very high temperatures.

Without predicting the possibility of large-scale extraction from sea water, the scientists reported that samples taken from Plymouth Sound and from a point about 25 miles from Plymouth contained appreciable and varying amounts of the metals.

In an earlier report to *Nature* (March 29), Dr. Carlisle suggested that vanadium known to exist in petroleum deposits came from the same salt-water animals that, upon decay, may have formed the petroleum.

New Uranium Conversion Process

▶ A NEW TECHNIQUE that produces nuclear fuel rods better and faster than existing processes was revealed at the 1958 Nuclear Congress in Chicago.

The "novel" preparation method uses a high temperature flame furnace instead of the complex wet chemical, and sometimes physical, processes presently used to convert uranium compounds to usable uranium dioxide rods.

The main objective of converting uranyl nitrate or uranium trioxide to uranium dioxide is to achieve greater density. Scientists want to pack the greatest possible weight of fuel into the smallest possible volume.

Eventually, the method may be used to prepare solid rods of nuclear fuel directly from the starting materials without first going through a powder stage, C. D. Harrington and A. E. Ruehle, Mallinckrodt Chemical Works, St. Louis, reported.

The new process involves feeding the starting material, uranium trioxide or uranyl nitrate, onto the top of some uranium dioxide fused in the hottest part of a hydrogen-methane flame or atomic hydrogen arc. The new material breaks down in the flame to form uranium oxide, which is stable at the very high temperature.

As feed material is added, a rod of crystalline uranium dioxide forms. The rod is continuously lowered by a drive mechanism such that the top end is always in the hottest part of the flame or arc.

The process was developed recently at the Atomic Energy Commission plant in St. Louis.

Book Condensations

Basic Concepts in Chemistry — George W. Watt — *McGraw-Hill,* 538 p., illus., $6.50. An elementary college text with the content delimited judiciously so as not to teach too much too early.

Rocket Experiment Safety: Safety Suggestions for the Rocket Hobbyist — DeWitt O. Myatt and David M. Paul and others — *Atlantic Research Corp.,* 36 p., illus., paper, single copies free upon request direct to publisher, Alexandria, Va. Telling the youthful or amateur scientist how to avoid painful or fatal accidents from which nothing is learned but which may frighten others away from this fascinating field.

Growth of Crystals: Reports at the First Conference on Crystal Growth, 5-10 March 1956 — In English Translation — A. V. Shubnikov and N. N. Sheftal, Eds. — *Academy of Sciences USSR (Consultants Bureau),* 294 p., illus., paper, $15. Containing 43 of the papers presented at this conference attended by more than 400 representatives of various branches of Soviet science and industry.

Splitting of Terms in Crystals — Hans A. Bethe — *Consultants Bureau,* complete English translation, 69 p., paper, $3. On the wave mechanics of crystals.

Instrumental Methods of Analysis — Hobart H. Willard, Lynne L. Merritt, Jr., and John A. Dean — *Van Nostrand,* 3d ed., 626 p., illus., $7.50. An almost completely re-written popular text.

Organic Electrode Processes — Milton J. Allen — *Reinhold,* 174 p., illus., $6.50. For the organic chemist but also for the novice.

Chemical Calculations: A Systematic Presentation of the Solution of Type Problems, With 1000 Chemical Problems Arranged Progressively According to Lesson Assignments — Bernard Jaffe — *World Bk.,* 3d ed., 180 p., illus., $2.20. A supplement to the chemistry textbook intended to overcome the student's shortcomings in mathematics.

Qualitative Analysis: An Introduction to Equilibrium and Solution Chemistry — Therald Moeller — *McGraw-Hill,* 550 p., illus., $6.50. Intended to lead the student logically through needed theoretical concepts while simultaneously providing a background of interesting experimental work.

Fundamental Concepts of Inorganic Chemistry — Esmarch S. Gilreath — *McGraw-Hill,* 421 p., illus., $7.50. Text for advanced undergraduates.

Molecular Physics: Volume 1, Number 1, January 1958 — H. C. Longuet-Higgins, Ed. — *Academic,* 98 p., paper, $3.50 per part, $13.30 per year (4 issues). Founded to bring together papers on the physics of molecules, of interest to chemists as constituting the basis of chemical theory.

Nuclear Structure — Leonard Eisenbud and Eugene P. Wigner — *Princeton Univ. Press,* 128 p., $4. A short descriptive summary. The treatment is largely non-mathematical.